Cassandra L. Quave *Editor*

Innovative Strategies for Teaching in the Plant Sciences

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Editor
Cassandra L. Quave
Department of Dermatology and
Center for the Study of Human Health
Emory University School of Medicine
Atlanta
Georgia
USA

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This volume is dedicated to the educators that came before us, who introduced generations to this beautiful science called botany. It is also dedicated to those who follow, with the hope that our collective experiences will help them to inspire and instill a love and curiosity for plants in their students.

Preface

In his 1996 paper on the history of problems in botany education, Hershey noted that "As a result of plant neglect, the general public, most precollege teachers, and many college-level biology teachers are generally illiterate about botany." While botany once held a principal role in biology education—even at the high school level—its presence in the curriculum as a core focus topic has been in decline since the early 1900s (Hershey 1996). Moreover, this steady decline in botany education has been compounded by the overall challenges faced in STEM (science, technology, engineering, and mathematics) education. We have reached a critical state in botany education and creative solutions to reinvigorating this field in the classroom are in order.

Awareness of the need for integration of more innovative teaching methods in the biological sciences to boost interest in STEM at large has grown among biology educators since the publishing of the recent landmark document *Vision and Change in Undergraduate Biology Education: A Call to Action* (Brewer and Smith 2011). This document, which was the result of a series of professional meetings and workshops by science educators across the United States (USA), was published by the American Academy for the Advancement of Science (AAAS) and funded by the USA National Science Foundation (NSF). One of the key areas recommended for change included a call for better integration of core concepts and competencies throughout the curriculum and a focus on student-centered learning. Moreover, the document called for engagement of the biology education community in the implementation of the proposed changes.

These changes are of particular importance for the field of botany, which is arguably becoming progressively neglected by educational institutions. This is underscored by recent trends towards the "phasing out" of botany lessons, courses, and even entire botany programs and departments at institutions across the United States. Unfortunately, this may not only result in a critical shortage of new scientists with expertise in this field, but it also comes at a time when trained botanists are most needed to address important emerging issues concerning biodiversity management, biotechnology, food security, and climate change.

Another challenge that we face as botany educators is that for those students who do have access to botany lessons, it can be difficult to cultivate interest in the material. Pedagogical techniques that rely heavily on rote memorization of plant names and characteristics are hardly stimulating to students, and in many cases, they may walk away from a course without ever seeing the “big picture” of why plants matter both to them as individuals and the world at large. In other words, without context, it is incredibly difficult—or even impossible—for students to become engaged with the plant world and make those crucial connections that are necessary for integration of knowledge into their long-term memory. The truth of the matter is that we need to foster student enthusiasm for the plant sciences in order to both encourage the growth of future experts in this field and to cultivate a global community of citizen scientists with an appreciation for and connection to their environment that is mostly plant-based. Ethnobotany, which is the interdisciplinary study of how people interact with plants, can be used to fill in this contextual gap in plant science education by helping students understand their personal and cultural relationship with plants, revealing the practical and persistent value of plants on an individual level.

In 2007, a group of scientists that were developing interdisciplinary undergraduate curricula in ethnobiology met to discuss some common problems encountered in this process. They decided to form the Open Science Network (OSN) to foster both the exchange of ideas and sharing of educational resources. Over the years since it was founded and with the financial support of the NSF, the OSN has brought educators from the natural and social sciences together in a series of workshops with the aim of developing educational standards and compiling resources for teaching initiatives in the field of ethnobiology. One major product of these efforts was the OSN’s report, *Vision and Change for Ethnobiology Education in the USA: Recommended Curriculum Assessment Guidelines* (McClatchey et al. 2013), which was modeled after the AAAS *Vision and Change* document. Like the original V&C document, the OSN report emphasized the need for the inclusion of core concepts and competencies in the curriculum. The idea of using ethnobiology as a tool to bring botany into context for students was highlighted as a means of meeting several of the core competencies listed in V&C, including those concerning the ability to tap into the interdisciplinary nature of science, the ability to communicate and collaborate with other disciplines, and the ability to understand the relationship between science and society. The importance of ethnobiology in the advancement of education in the plant sciences is further developed in a series of case studies in the present volume.

This volume brings together a collection of papers addressing the challenges of botanical education in the twenty-first century, while highlighting novel approaches to engaging students in botanical curricula with the aim of inspiring a new generation of students and instructors. While the approach to education in the plant sciences is explored from varying perspectives, a common focus here is on the innovative ways through which educators can both enrich the plant science content being taught and improve upon student engagement in the study material. Drawing on contributions from scholars from the United States, Europe, and Canada, various teaching methods are demonstrated and both the successes and challenges of different methods are explored. Uniquely to this volume, several chapters describe how core principles from ethnobotany can be used to foster the development of connections between students, their environment, and other cultures around the world.

The 18 chapters included here are organized into five focus areas: (1) defining the needs of educators and students, (2) introducing fundamental skills, (3) connecting students to plants, (4) teaching through field experiences, and (5) integrating technology. These contributions represent a broad spectrum of approaches in botanical education, ranging from community outreach efforts, K-12 education, distance learning, and university programs and courses. Central to the theme of the volume is the concept of creating a sense of connectivity to nature as a tool for capturing student interest in the study material, and helping them to appreciate the critical role that the plant sciences play in everyday life. Perhaps most useful to educators is that many of the contributions also include examples of how a wide range of teaching techniques can be used in plant science education, including authentic learning, student-centered learning, active learning, research-based learning, and mind/brain-based techniques, among others. Ranging from veteran teachers to new faculty, the contributing authors discuss their vision for the future of plant science education and provide concrete examples of how they incorporate local resources and technology into a hands-on approach to teaching and learning in this field.

Cassandra L. Quave
Assistant Professor and Herbarium Curator
Emory University
School of Medicine,
Department of Dermatology
Emory College of Arts and Sciences,
Center for the Study of Human Health

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Contributors

Ursula M. Arndt Department of Anthropology, Kwantlen Polytechnic University, Richmond, BC, Canada

Department of Archaeology, Simon Fraser University, Burnaby, BC, Canada

Cedric Barrett Baker Department of Pharmacy Practice/Center for Clinical Research CCR-15, College of Pharmacy and Health Sciences, Mercer University, Atlanta, GA, USA

Alpharetta, GA, USA

Janelle Marie Baker Department of Anthropology, McGill University, Montreal, QC, Canada

Keri Barfield Botanical Research Institute of Texas, Fort Worth, TX, USA

Michael Benedict (Mohawk) Forester Plant Ecologist, Akwesasne, NY, USA

Bradley C. Bennett Department of Biological Sciences, Florida International University, Miami, FL, USA

K.W. Bridges Botany Department, University of Hawai‘i at Manoa, Honolulu, HI, USA

Sunshine L. Brosi Department of Biology, Frostburg State University, Frostburg, MD, USA

Al Keali‘i Chock Department of Botany, University of Hawai‘i at Mānoa, Honolulu, HI, USA

Maria Fadiman Department of Geosciences, Florida Atlantic University, Boca Raton, FL, USA

Lisa Carolina Gonzalez College of Agriculture and Natural Resources, University of Maryland Extension, Cockeysville, MD, USA

Gokhan Hacisalihoglu Department of Biology, Florida A&M University, Tallahassee, FL, USA

Karen C. Hall Department of Research, Botanical Research Institute of Texas, Fort Worth, TX, USA

Patricia Harrison Botanical Research Institute of Texas, Fort Worth, TX, USA

Ryan D. Huish Department of Biology, Hollins University, Roanoke, VA, USA

Leslie Main Johnson Centre for Social Science, Athabasca University, Athabasca, AB, Canada

Edmonton, AB, Canada

Kelly Kindscher Environmental Studies Program, University of Kansas, Lawrence, KS, USA

Will McClatchey Department of Research, Botanical Research Institute of Texas, Fort Worth, TX, USA

Raymond Pierotti Department of Ecology and Evolutionary Biology, University of Kansas, Lawrence, KS, USA

Cassandra L. Quave Department of Dermatology and Center for the Study of Human Health, Emory University School of Medicine and Emory College of Arts and Sciences, Atlanta, GA, USA

Nanci J. Ross Department of Biology, Drake University, Des Moines, IA, USA

Jan Salick Missouri Botanical Garden, St Louis, MO, USA

Valentina Savo Hakai Network for Coastal People, Ecosystems and Management, Simon Fraser University, Burnaby, BC, Canada

April T. Sawey Department of Education, Botanical Research Institute of Texas, Fort Worth, TX, USA

Laura Shiels Department of Biology, University of Hawaii, Hilo, HI, USA

John Richard Stepp Department of Anthropology, University of Florida, Gainesville, FL, USA

Sofia A. Vougioukalou School of Anthropology and Conservation, University of Kent, Canterbury, Kent CT2 7NS, UK

Gail E. Wagner Department of Anthropology and Associated Faculty, Environment and Sustainability Program, University of South Carolina, Columbia, SC, USA

Author Biographies

Ursula M. Arndt, Ph.D., has a Master's degree in Anthropology (University of Mainz, Germany) and recently received her Ph.D. in molecular Archaeology/Palaeogenetics from Simon Fraser University in Vancouver, Canada. Her Ph.D. investigated the genetic diversity of pre-industrial whaling humpback whales and the potential of ancient DNA to improve the collaboration between Archaeology and Conservation Biology. She has been working with an NGO on wildlife forensic projects using ancient DNA technology for the past 4 years. In addition to her research, she has been focused on developing her teaching knowledge and experience through teaching assistantships and courses such as the Instructional Skills Workshop (ISW). In 2013, Dr. Arndt taught *Introduction to Biological Anthropology* as a sessional Instructor at Kwantlen Polytechnic University in Surrey (near Vancouver), Canada.

Cedric Barrett Baker, Pharm.D., is an ethnopharmacist, food-ethnopharmacognosist and medical botany historian. He holds a Doctor of Pharmacy degree from Mercer University, College of Pharmacy and Health Sciences, where he studied Pharmacognosy with (the late) Dr. Hank Cutler. Dr. Baker has postdoctoral research training from the NIH-ODS and the NIH-NCI Cancer Prevention Division with Dr. John Milner, et al. He has studied ethnobotany and ethnopharmacology at the graduate level with Dr. Dennis McKenna and Kat Harrison at the University of Minnesota-Twin cities. His specialty is in the area of traditional functional/medicinal foods and diets, and their integrative use in traditional dietetics, ethnomedicine, and biomedicine (Southeast Asia/Italy). Dr. Baker was the Sonnedecker Visiting Scholar in the History of Pharmacy for Fall 2009 at the AIHP in the University of Wisconsin School of Pharmacy, Madison. He has several peer-reviewed publications in integrative therapeutics, functional foods, history of pharmacy, and the phytopharmacology of plant foods.

Janelle Marie Baker, M.S., is a Ph.D. student in Anthropology at McGill University. She is a Warren Fellow at the McGill Institute for the Study of Canada, a Vanier Canada Graduate Scholar, and a Canadian Federation of University Women Canadian Home Economics Association Fellow. Her research is on Cree perspectives on wild food contamination in the oil sands region in Canada. This research topic is a response to community's concerns voiced during 6 years of applied work that she did for First Nations doing traditional land use studies and traditional environmental knowledge research and training. She has designed and taught an ethnobotany course for the International Indigenous Studies Program at the University of Calgary, and she continues to tutor for the Anthropology Department at Athabasca University (including an online community-based research methods course that she designed). Ms. Baker has also done ethnoecology research and undergraduate instruction for an NGO in Indonesian Borneo.

Keri Barfield is the Research Programs Manager for the Botanical Research Institute of Texas (BRIT). She has worked in the past on the various international and local research projects at BRIT that included the Andes to Amazon Biodiversity Program and research in New Guinea. She has a background in biology, botany, and ecology. She is a Research Associate with Texas Christian University, where she is currently working with colleagues on phylogeography of two specific pine species. In addition, she has been the project manager for the Open Science Network in Ethnobiology (OSN). The OSN is a collaborative network open to educators and students interested in the exchange of innovative curricula and educational resources that advance the field of ethnobiology. Funded by the National Science Foundation (NSF), the OSN uses open technology to facilitate the exchange of educational techniques, materials, and experiences across institutional and international borders.

Michael Benedict, M.S., received an AAS Degree in Forestry from Paul Smiths College, N.Y., 1976, an AAS Degree in Natural Resources from Haskell Indian Nations University, KS, 1995, a B.S Degree in Systematics and Ecology from the University of Kansas, KS, 1998 and an M.S. Degree in Forestry from the University of Minnesota, MN, 2001. His Master's thesis covered the "Ecology of Black Ash: A study of ring growth and regeneration and its relationship to Native Black Ash Basketmakers." He is a former instructor at the North House Folks School in Grand Marais, Minnesota. He learned basket making from two elders from the Akwesasne Mohawk Nation in the early 1980s, learning both weaving techniques and making basket-making tools. Mr. Benedict is currently working as a Professional Forester in Colorado.

Bradley C. Bennett, Ph.D., is a Professor in the Department of Biological Sciences at Florida International University in Miami, Florida. He earned a B.A. (Biology and Geology/Geography) from Bucknell University, an M.S. (Biology) from Florida Atlantic University, and a Ph.D. (Botany) from the University of North Carolina at Chapel Hill. From 1988 to 1992, he was a postdoctoral fellow and research associate at the New York Botanical Garden's Institute of Economic Botany. He was the 2004-2005 president of the Society for Economic Botany and currently is an associate editor of the journal *Economic Botany*. He is also a member of the American Botanical Council's Advisory Board and serves on NIH's National Center for Complementary and Alternative Medicine Special review panels. His main research focus is neotropical ethnobotany and ethnopharmacology. Dr. Bennett's book *Ethnobotany of the Shuar of Amazonian Ecuador* won the 2006 Mary W. Klinger Book Award from the Society for Economic Botany.

K. W. Bridges, Ph.D., recently retired from the University of Hawai'i at Mānoa. His early academic career started in zoology, with an M.S. degree from the University of Hawai'i. He moved to the broader field of Biology for his Ph.D. degree where he used the then emerging access to computers and computer graphics to study quantitative definitions of leaf shape. He joined the NSF-sponsored Desert Biome study headquartered at Utah State University after graduation. After a few years, he returned to the University of Hawai'i to work with the Island Ecosystems research project and to teach in the Botany Department. His wide academic interests, which generally bringing quantitative techniques into a variety of disciplines, led him to teach and do research in botany, geography, computer science, and tropical agriculture. The major focus of his research has been on systems ecology, marine flowering plants, island ecosystems, and ethnobotany. He was deeply involved in teaching introductory courses through his career and was recognized with the UH Regents Medal for Excellence in Teaching. Dr. Bridges has collaborated with Dr. McClatchey on a number of field studies and innovative educational initiatives.

Sunshine L. Brosi, Ph.D., is a tenured Assistant Professor of Ethnobotany at Frostburg State University in western Maryland. She has coordinated the undergraduate Ethnobotany Major, one of only two B.S. level programs, since it began in 2007. She also coordinates majors in Wildlife and Fisheries Biology and Interpretive Biology and Natural History. Dr. Brosi is a Co-PI on the Open Science Network, an educational project funded by The National Science Foundation. She has taught over a dozen courses in plant biology and ecology including Plant Taxonomy, Dendrology, Economic Botany, Forest Ecology and Conservation, and Introduction to Ethnobotany. She is an editor for the Life Discovery Education Digital Library's EconBotEd portal for ethnobiological educational resources and a member of the education committee for the Society for Economic Botany. She received a B.A. in Environmental Studies from Warren Wilson College in Asheville, North Carolina, a M.S. in Forestry from the University of Kentucky, and a Ph.D. in Natural Resources from the University of Tennessee, Knoxville.

Al Keali'i Chock, Ph.D., was born and raised in the Territory of Hawai'i. He attributes his interest in Hawaiian culture to his teacher-mother (fourth grade), and botany his high school science teachers. He attended Hannibal-LaGrange College (A.A.), University of Hawai'i at Mānoa (UHM) (B.A., M.S. in Botany), and University of Michigan (AbD). In non-academic situations, nearly all of which involved people and plants, Dr. Chock worked for the U.S. government for 38 years: National Park Service, European Exchange Service, Army & Air Force Exchange Service, U.S. Department of Agriculture (USDA), Environmental Protection Agency (Office of Pesticide Programs) and Food & Agriculture Organization of the United Nations (FAO). He retired in 1992 from the USDA Foreign Service. He began teaching Botany 105 (Economic Plants of Hawai'i and the Pacific) in 1961 and had the course name changed to Ethnobotany in 1964. Since 1992, Dr. Chock has been a UHM Botany adjunct faculty member, where he teaches the Botany 105 Honors section and summer session, and Hawaiian Ethnobotany. He is also a core team member of the Open Science Network in Ethnobiology (OSN). Visit his website at http://www.alchock.info/.

Maria Fadiman, Ph.D., conducts ethnobotanical research (how people use plants) in a global context. She was named one of National Geographic's Emerging Explorers in 2006. In addition to conducting most of her studies in the rainforests of Latin America, she has also researched in Africa, Asia, and Oceania. She currently works on an international cross-cultural study of people's use of plants, and how their utilization can encourage cultural and ecosystem preservation. She completed her undergraduate work at Vassar College, M.A. at Tulane University, and Ph.D. at the University of Texas at Austin. She is an associate professor at Florida Atlantic University in the department of Geosciences.

Lisa Carolina Gonzalez, M.S., is a *Gardening for Nutrition Educator* with the University of Maryland Extension where she works with limited income communities to establish and implement food gardening education programs. She holds a B.A. in Environmental Education from Warren Wilson College and a Graduate Teaching Certification in Waldorf Education from Antioch New England University. In addition to her work as an educator she has a private practice working with clients to create and maintain home vegetable, fruit, and herb gardens purposely designed to help clients reach their individual health goals. Ms. Gonzales received a Graduate Certificate in Medical Herbalogy and a Master's of Science degree in Clinical Nutrition and Integrative Health from Maryland University of Integrative Health.

Gokhan Hacisalihoglu, Ph.D., is Professor of Biology and Plant Biology at Florida A&M University, Tallahassee, Florida, where he teaches Plant Biology and General Biology courses. He received his Ph.D. in Plant Physiology from Cornell University. His research focuses on plant nutrition, sensing, signaling, uptake of nutrients, as well as Epigenetic Mechanisms. He authored numerous scientific publications and a lab manual book. He is the recipient of several teaching and research awards including FAMU's Advanced Teacher of the Year, Teacher of the Year, Research Excellence Award, and Best Professor at Art & Sciences Award. He is a Courtesy Professor with University of Florida and Florida State University. Dr. Hacisalihoglu is a member of American Society of Plant Biologists, Sigma Xi, and iPlant Collaborative. He lives in Tallahassee, Florida, with his wife and daughter.

Karen C. Hall, Ph.D., grew up with 50 acres of playground in the mountains of North Carolina, and this inspired a lifetime of interest in nature, including the embedded human component. She completed a B.S. in Biology (Western Carolina University), M.S. in Botany, and Ph.D. in Plant Physiology (both at Clemson University). Her dissertation work was focused on knowledge structure and management of medicinal plant practitioners within the Eastern Band of Cherokee Indians in North Carolina. As a living example of this work, she designed and developed the Cherokee Worldview Garden. She is intensely interested in traditional ecological knowledge with specific foci in landscape management, fiber and dye technologies, and sustainable practices. Her childhood played a significant role in a desire to create more people with curiosity and enthusiasm for nature and, thus, she is also an educator. Karen is the former Director of the SC Master Naturalist and Master Gardener programs. Most recently, she moved to Texas to become the Applied Ecologist for the Botanical Research Institute of Texas, where her primary focus is restoration ecology and outreach.

Patricia Harrison, M.Ed., is Vice President, Director of Education, for the Botanical Research Institute of Texas (BRIT), a non-profit research and education organization dedicated to conservation. She has helped guide the growth of the organization and leads its dynamic education program designed to connect people of all ages to nature in ways that build environmental literacy and promote stewardship of our natural resources. She currently is developing an Environmental STEM Innovation Center to engage schools and the public with BRIT's botanical research. Pat is PI for the NSF RCN-UBE Open Science Network for Ethnobiology and contributing editor to the Vision and Change for Ethnobiology. She has authored numerous botany curriculum resources for elementary learners and is a member of the Education Committee for the Society of Economic Botany.

Ryan D. Huish, Ph.D., is an Assistant Professor of Biology at Hollins University, a small liberal arts women's institution in Roanoke, Virginia, where he teaches Plant Biology, Conservation Biology, Ethnobotany, Plants of Virginia, Appalachia: People, Place, and Plants, and Plants in Poetry and Art. He received his B.S. degree from Brigham Young University, studying botany and cultural anthropology, and earned his Master's and Ph.D. in Plant Sciences at the City University of New York and The New York Botanical Garden. His research interests incorporate an interdisciplinary approach to address basic and applied questions in ethnobotany, ecology, and plant conservation. Some current research projects he is involved with include Tongan medical ethnobotany, community-mediated conservation of sandalwood, the conservation of several rare Appalachian plants including piratebush and smooth coneflower, and the effects of climate change on sugar maple products and the corresponding socio-economic responses. Visit his website at http://botanicallyspeaking.wordpress.com/.

Leslie Main Johnson, Ph.D., is an ethnobiologist and ethnographer who teaches ethnography, research methods, and ethnobiology at Athabasca University, a distance learning university located in Alberta, Canada. Her research interests center on traditional knowledge research, ethnoecology, and ethnobiology. Her dissertation research focused on medical ethnobotany of the Gitxsan Nation of northwestern British Columbia. Her publications include *Trail of Story, Traveller's Path, Reflections on Ethnoecology and Landscape* (2010, AU Press), and Landscape Ethnoecology, Concepts of Biotic and Physical Space (co-edited with Eugene S. Hunn, 2010, Berghahn Books), as well as chapters in an edited volumes on landscape ethnoecology (2011) and a recent co-edited textbook on Ethnobiology (Wiley-Blackwell 2011).

Kelly Kindscher, Ph.D., is a passionate advocate for native plants and their uses, native landscapes, and wild places. He works at the University of Kansas at the Kansas Biological Survey, where he conducts research throughout Kansas, the Midwest, and the Great Plains and Rocky Mountain states; and in the Environmental

Studies Program, where as a professor he mentors students and teaches ethnobotany and the program's capstone course. He is the author of two books: *Edible Wild Plants of the Prairie* and *Medicinal Wild Plants of the Prairie*, and has published over 100 scholarly articles and technical reports on: native prairie plants; prairie and wetland ecology and restoration; cultural uses of edible and medicinal plants, and management of native plant communities. Currently he is focusing much of his attention on collecting medicinal plants and searching for ethnobotanical data that help support the use of native plants for the *KU Native Medicine Plant Research Program.*

Will McClatchey, Ph.D., is currently Director of Research, Botanical Research Institute of Texas, Fort Worth, Texas, grew up in the Southwestern USA, and then attended high school and college in the Northwest USA. He earned his B.Sc. degrees in Anthropology and Pharmacy from Oregon State University and then worked as a community and consultant pharmacist for 10 years, during which time he earned an M.S. in Botany and Range Science (Ethnobotany) from Brigham Young University and a Ph.D. in Botany (Evolutionary Biology) from the University of Florida. He has conducted ethnobotanical research in the Southwest Pacific region and SE Asia since 1990. His research focuses on understanding systems function of artificial ecosystems produced by humans, and how management decisions within these systems are impacted by changing environmental conditions. For 15 years he was Professor of Botany at University of Hawai'i, where he developed the world's first B.Sc. in Ethnobotany degree program and has taught thousands of students about Ethnobiology and Conservation Biology. He particularly enjoys working with students in field settings where real research is accomplished.

Raymond Pierotti, Ph.D., received a B.A. degree from the University of California in 1973, an M.A. degree from California State University in 1976, and a Ph.D. from Dalhousie University in Population and Evolutionary Ecology in 1980. He is currently a Professor of Ecology and Evolutionary Biology at the University of Kansas, where he has worked with Haskell Indian Nations University and mentored more than 50 Native American students to bachelor's degrees and 12 Native American students to graduate degrees. He has authored more than 80 papers and recently published *Indigenous Knowledge, Ecology and Evolutionary Biology*. 2011. Routledge, Taylor and Francis Group, New York & London. 264 pp, and *The World According to Is'a: Combining Empiricism and Spiritual Understanding in Indigenous Ways of Knowing*. In *Ethnobiology*, 2011. Wiley-Blackwell, Hoboken, NJ. His current research is co-evolution between *Homo sapiens* and *Canis lupus* and how each species has shaped the other.

Cassandra L. Quave, Ph.D., is a medical ethnobotanist with research interests in the documentation and analysis of botanical remedies used in the treatment of infectious disease. She completed her B.S. at Emory University in 2000, Ph.D. at Florida International University in 2008, and postdoctoral studies at the University of Arkansas for Medical Sciences and Emory University. To date, she has published more than 40 scientific works and has been the PI on three National Institutes of Health (NIH) grants. She has been involved in the Open Science Network in

Ethnobiology as a core team member since 2010 and is currently the Vice President of the organization. She currently serves on the editorial boards of the *Journal of Ethnobiology and Ethnomedicine, Evidence Based Complementary and Alternative Medicine,* and *Ethnobiology and Conservation* and on regular grant review panels for the NIH National Center for Complementary and Alternative Medicine (NCCAM). She holds a joint appointment as Assistant Professor with the Emory University School of Medicine Department of Dermatology and the Emory College of Arts and Sciences Center for the Study of Human Health in Atlanta, GA, where she leads ethnobotanical research initiatives and teaches undergraduate courses on medicinal plants, food, and health. Visit her website at http://www.etnobotanica.us/ .

Nanci J. Ross, Ph.D., completed her doctoral studies at the University of Connecticut in 2008 with Greg Anderson. Her dissertation investigated the impact of ancient Maya forest gardens on the tree species composition of the modern forest of Northwestern Belize. She has continued her exploration of the interactions of cultures and ecosystems through investigating the dynamics of people, plant community ecology, and climate change in the high diversity alpine meadows of the Eastern Himalaya. Dr. Ross is an Assistant Professor of Biology at Drake University in Des Moines, IA.

Jan Salick, Ph.D., Senior Curator of Ethnobotany at the Missouri Botanical Garden, has a Bachelor's degree from University of Wisconsin, Madison, a Master's from Duke University, a Ph.D. from Cornell University; and a post-doc at The New York Botanical Garden. She was a Professor at Ohio University, Senior Fellow at University of Oxford, UK, and is currently Adjunct Professor at Washington University, St. Louis. She has been doing ethnobotany research since the early 1970s. She began working in Southeast Asia, transferred to South and Central America before concentrating on the Himalayas for the last 15 years. She is interested in traditional land use management, crop domestication, and climate change and has over 60 peer-reviewed publications and two books. She receives funding from diverse sources, including the National Science Foundation, National Institute of Health, National Geographic Society, The Nature Conservancy, Mellon Foundation, and Ford Foundation.

Valentina Savo, Ph.D., is an ethnobotanist whose research aims to include a more complex view of the relationships between humans and the environment. Since 2003 she has been working on several different projects spanning from Mediterranean plant ecology, bioclimate, ethnobotany, Traditional Ecological Knowledge (TEK), and plant iconography. She has recently been awarded a postdoctoral fellowship from the Foreign Affairs and International Trade of Canada and has joined the Hakai Network as a Hakai Postdoctoral scholar. Her research explores Coastal First Nations' observations of and adaptations to climate change in British Columbia. Dr. Savo has an excellent track record of publications (in peer-reviewed journals and books) and fellowships with a wide network of international collaborations.

April T. Sawey, Ph.D., is a researcher and environmental educator working with a non-profit conservation organization to promote environmental stewardship through awareness of the crucial role plants play in our daily lives and in the sustainability of our planet. She has experience as a K-16 teacher, academic dean, and administrator, but now applies her skills in the non-formal learning environment. After completing her Bachelor's degree in Biology and her Master's degree in Education, she decided to expand her knowledge of the natural world by choosing a science education doctoral program in which she could focus on environmental science and education. Her research interests include phenomenological approaches to emotional connections in experiential learning, significant life experiences, place-based and mind/brain education. She lives in Fort Worth with her husband Michael and her daughter Alara. They enjoy native plant and vegetable gardening—sometimes in their front yard when their HOA will let them get away with it! Dr. Sawey is a Research and Evaluation Specialist at the Botanical Research Institute of Texas.

Laura Shiels, M.S., is an ethnobiologist with research interests in the relationships among the environment, human health and social wellbeing, and the human condition. She is a Lecturer for the Department of Biology at the University of Hawai'i, Hilo, and a Research Project Associate with the Daniel K. Inouye School of Pharmacy and the United States Department of Agriculture. She studied herbal medicine at the Southwest School of Botanical Medicine and holds a B.S. in Environmental Studies from the University of Nevada, Las Vegas, and a MS in Botany, Ethnobotany Track, from the University of Hawai'i Mānoa. She has conducted ethnobiological research with various cultural groups around the world, including the Owambo, Herrero, Damara, and Himba of Namibia, and rural communities in Nicaragua, Puerto Rico, and Hawai'i.

John Richard Stepp, Ph.D., is Associate Professor of Anthropology at the University of Florida. He is occasionally a visiting professor at the University of Gastronomic Sciences in Pollenzo, Italy and Minzu University in Beijing, China. From 2008-2009 he was the Wilder Professor of Botany at the University of Hawai'i. He has conducted ethnobiological research over the last two decades in Central America, Mexico, North America, and Southeast Asia. His research explores persistence, change and variation of traditional ecological knowledge, and ethnobotany. Much of this work has focused on wild food plants and medicinal plants. His work has also focused on patterns in the distribution of biocultural diversity. Other research interests include the anthropology of food, medical anthropology, visual anthropology, GIS and land use change, and human perceptions of climate change. He is the founding editor of the *Journal of Ecological Anthropology*, former editor of *The Journal of Ethnobiology*, and currently senior associate editor of *Economic Botany*, associate editor of the Journal of *Ethnobiology and Ethnomedicine*, and associate editor of the *Journal for the Study of Religion, Nature and Culture*. He is also involved in documentary and ethnographic film production on topics both related and unrelated to his primary research.

Sofia A. Vougioukalou, Ph.D., is a medical ethnobiologist with a background in biology, medical anthropology, and impact evaluation. She is an Honorary Research Associate at the School of Anthropology and Conservation at the

University of Kent and a Public Engagement Associate for Health Research at the Elizabeth Blackwell Institute at the University of Bristol. She previously worked as a Postdoctoral Research Associate at King's College London, undertaking an ethnographic evaluation of a participatory healthcare improvement intervention that involved patients and care providers as co-designers of improved intensive care and lung cancer services using filmed narratives of patient experiences collated at the University of Oxford. She has taught at King's College London, the University of Kent, and Canterbury Christ Church University courses on patient and public involvement, ethnography, evaluation, cross-cultural psychiatry and medicinal plant use. She is also an external examiner and supervisor of M.Sc. theses on health and climate change at the University of South Pacific in Fiji. Her area expertise is in Polynesia and the Mediterranean region.

Gail E. Wagner, Ph.D., is an Associate Professor of Anthropology and associated faculty in the School of the Environment at the University of South Carolina, Columbia. She earned her Master's and Doctorate degrees in Anthropology from Washington University in St. Louis. Dr. Wagner researches the relationships between people and plants, both past and present, in the southeastern United States. Her current paleoethnobotanical projects focus on periods of social transition and changing foodways. She has particularly delved into human relationships with maize (*Zea mays*), beans (*Phaseolus vulgaris*), tobacco (*Nicotiana*), and sumpweed (*Iva annua*). Her ethnobotanical projects focus on biocultural diversity as expressed through botanical knowledge. She heads an archaeological research project tracing the origins and demise of the chiefdom of Cofitachequi in central South Carolina. Dr. Wagner won an award for her teaching of undergraduate students at the University of South Carolina, and has spent many years thinking and publishing on education.

Part I
Defining the Needs of Educators and Students

Chapter 1
Carrying Plant Knowledge Forward in the USA

Patricia Harrison

1.1 Background

At a time when the demand for botanical expertise has been the most critical to addressing threats to biodiversity and the environment, the supply of qualified botanists is shrinking. A study led by the Chicago Botanic Garden in 2010 indicates that botany education has been declining since the early 1900s, resulting in the loss of critical infrastructure needed to support botanical training (Kramer et al. 2010). Herbaria are being disbanded and universities continue to eliminate traditional botany courses as plant science is integrated into multidisciplinary studies (Kramer et al. 2010). Research indicates individuals are not being trained with the skills and knowledge needed to fill essential jobs in science and resource management (Sundberg et al. 2011).

1.1.1 Botanical Training and Economics

From an economic perspective, this decline is indicative of a larger problem with the education system in the USA. For over a century, America's economic strength was built on its scientific capacity for innovation to meet the world's manufacturing and technology needs. The nation was jolted out of complacency when unemployment began to rise as more and more jobs were being moved to other countries due to a workforce unprepared for the jobs that were in demand (Stephens and Richey 2013). The acknowledgment led to a hard look at the public education system that revealed how far the USA lagged behind other countries in math and science scores, a full decade after the National Science Education standards were implemented (NCES 2011). Some alarming aspects of this report include the following statistics and predictions (NMSI 2013):

P. Harrison (✉)
Botanical Research Institute of Texas, 1700 University Drive,
Fort Worth, TX 76107, USA
e-mail: pharrison@brit.org

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- US students recently finished 25th in math and 17th in science in the ranking of 65 countries (NCES 2011).
- Women currently constitute 48% of the US workforce but hold just 24% of the US jobs in STEM (science, technology, engineering, and mathematics; Beede 2011).
- Sixty percent of the new jobs that will be open in the twenty-first century will require skills possessed by only 205 of the current workforce. Two-thirds of those jobs will require at least some post-secondary education (NCMS 2000).
- US scientists produced more than 40% of scientific papers in 1981, but now that number has shrunk to 29%. The USA is no longer the leader in the field of research as China leads the emerging nations with 1.4 million researchers. For the first time, over half of US patents are being awarded to non-US companies (Ratchford and Blanpied 2010).

In a nation with so many advantages, why has the US education system lost its competitive edge? One of the cultural trends that we are less proud is the outbreak of television reality and game shows that clutter the minds of countless Americans. One such show is called, "Are You Smarter Than a 5th Grader?" in which contestants are asked questions that fifth graders should know. Yet, if one listened to fifth graders speak, mere interpretation of their conversations would likely be challenging. Morphed words and abbreviations used in instant messaging (IM) and texting are becoming part of the language code young people use. This modern phenomenon reveals one of the big issues in our education system. Technology is changing the way our young people think and learn…and communicate. The challenge in education is to adapt to changing students with different learning styles.

In addition, schools are struggling with limited financial and human resources to meet the demands of increased numbers of students they must serve. A high percentage of students enter with language challenges and deficiencies in basic reading and math skills. Most are adept at basic technology skills but are lacking in communication skills and the ability to think critically. The need is for an education system that prepares students for jobs in the twenty-first century, some of which will require skills and technology we cannot imagine (P21 2011).

In an effort to address this growing concern, a plethora of new tools and initiatives have been launched within this decade. The nation is now facing the acknowledgment that to be competitive in the global economy, we need to be preparing students who can "think for a living" and can apply their thinking to complex, real-world problems, using scientific and technological knowledge (Alberts 2013).

In 2009, the White House announced a new campaign for promoting STEM education called "Educate to Innovate" (White House 2009). The administration's goal is to move American students higher to the top in science and math achievement over the next decade. President Obama has identified three overarching priorities for STEM education: (1) increasing STEM literacy so all students can think critically in science, mathematics, engineering and technology; (2) improving the quality of math and science teaching so American students are no longer outperformed by their peers in other nations; and (3) expanding STEM education and career opportunities for underrepresented groups, including women and minorities. Major funding for education has been committed to this initiative through both federal and business partnerships.

The Framework for twenty-first Century Learning focuses on the integration of skills into core academic subjects. It emphasizes the “3 C’s” essential for success in today’s world: critical thinking and problem solving, communication, and collaboration. It recommends integration of these three skills into the teaching of all core subjects, not just science (P21 2011).

The National Research Council has announced the development of *The Next Generation Science Standards* (NGSS) that are being called the “fewer, clearer, and higher standards” (Achieve 2013). These build on literacy and math from a science education perspective. The hope is that new guidelines will focus on not only what it will take to be a successful student, but also what it takes to be a successful employee. They take a firm stand on controversial topics, such as evolution and climate change, as essential to a high-quality science education. To date, 26 states have adopted NGSS for their schools, while some states are rejecting them due to the inclusion of evolution and climate change (Stage et al. 2013).

The trend in education, being reinforced through the new standards, is multidisciplinary learning (Brewer and Smith 2011). At all levels, sciences such as botany are not being taught in isolation but are integrated into multidisciplinary science courses such as environmental science or ethnobotany. Students are being trained as generalists, not specialists (Kramer et al. 2010).

1.2 Challenges in Botanical Education

1.2.1 Obstacles to Teaching in the Plant Sciences

In a local investigation, K-12 educators representing multiple disciplines were surveyed about their botanical knowledge. Results indicate a broad spectrum of interest and aptitude in passing along knowledge to the next generation. Of the educators surveyed, representing multiple disciplines of teaching, there was a direct correlation between a teacher’s interest in the three categories of plants sciences and their knowledge. Yet, on an individual basis, there was no correlation between self-ranking of their plant knowledge and the level of plant science they were teaching. About 57 % of the early childhood educators ranked their knowledge about plants greater than elementary and middle school teachers and their interest in plants greater than elementary teachers. Early childhood teachers also included how plants are used by people in their curriculum more than all other grade levels (Harrison 2013; Fig. 1.1).

When asked about the obstacles for including plants in their curriculum, the majority of respondents indicated that plant studies are not well represented in their state standards, and therefore not in their curriculum framework. The second greatest obstacle was time, i.e., the time to find and incorporate lessons on plants while managing to cover all the necessary objectives during the school year. At the middle school and high school level, some teachers expressed their own lack of knowledge about plants as a hindrance from including it in their curriculum. Others claimed

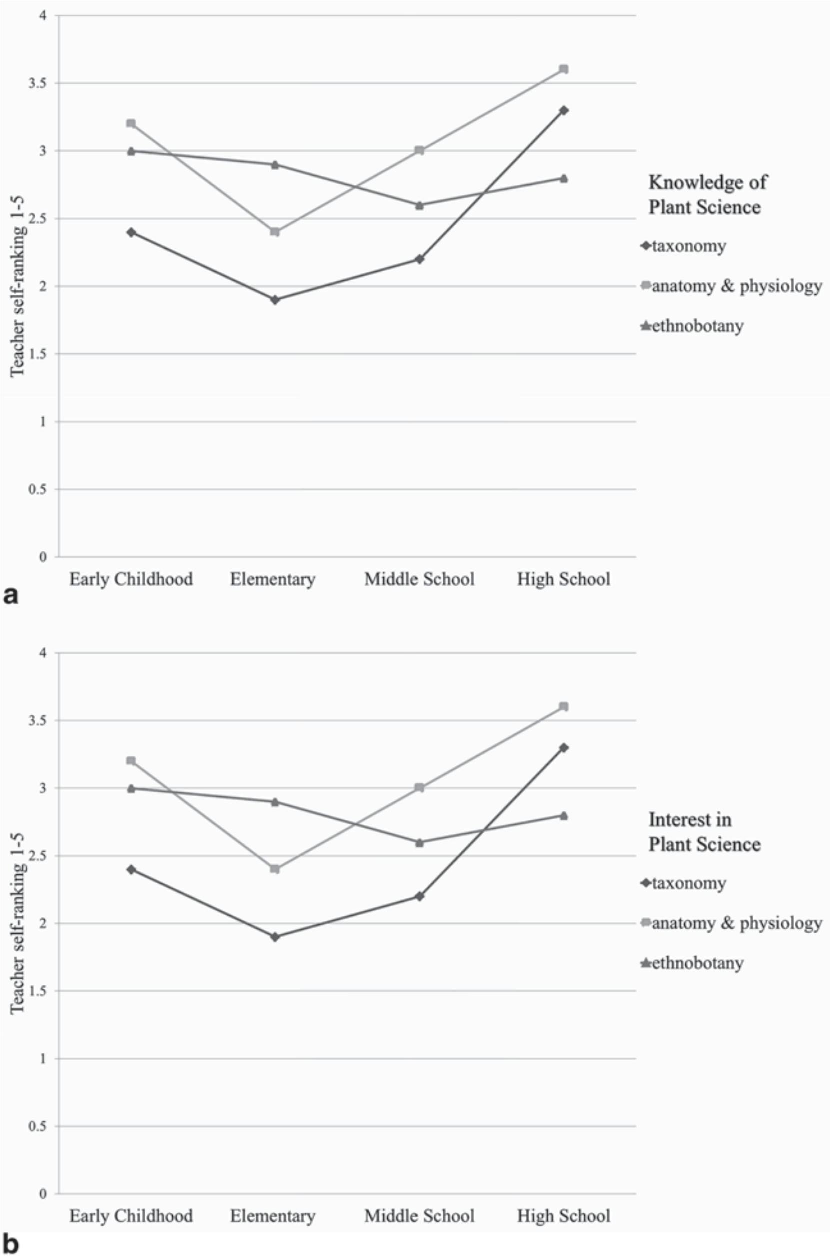

Fig. 1.1 **a** Survey of K-12 educators ranking their knowledge of plant science. **b** Survey of K-12 educators ranking their interest in plant science

they did not have the indoor and outdoor space to give students direct experiences with plants. Although this survey represents a regional study in the Dallas/Fort Worth metroplex, it mirrors a crisis in botanical science education across the USA.

1.2.2 Grand Challenges for Botanical Capacity

In a report on the nation's progress, the National Research Council of the National Academy identified the twenty-first century grand challenges for the US science and land management agenda (NRC 2001). The challenges included (1) managing habitats to sustain biological diversity and ecosystem functioning in a changing climate, (2) maintaining sustainable food production for a growing population with food plants that adapt to a changing environment, (3) understanding the earth's biogeochemical cycles and how they are being disturbed by human activities, (4) predicting climate variability to mitigate future impacts of climate on biodiversity and ecosystem functioning, and (5) expanding sustainable alternatives to fossil fuels through the use of biological systems (Kramer et al. 2010).

A decade later, a comprehensive study led by the Chicago Botanic Garden and Botanic Gardens Conservation International USA, as outlined in a report titled, "Assessing botanical capacity to address grand challenges in the United States," reexamined these challenges in light of declining botanical capacity (Kramer et al. 2010). The purpose of the study was to create a "score card" on the nation's performance on skills needed to meet environmental challenges of the twenty-first century. The report revealed significant changes over the past two decades in the demands placed on botanical education and the resources available to it, including a skilled workforce and financial and management support for research and education. Specifically, it delineated areas requiring botanical expertise as part of a multidisciplinary approach. It concluded that without adequate botanical infrastructure and expertise, our nation's science and land management agenda will increasingly be impaired. The study identified critical gaps in botanical capacity with recommendations to address those gaps (Kramer et al. 2010). Only the education and training components will be addressed here.

1.2.3 Loss of Botanical Degree Programs

The US Department of Education reports that undergraduate degrees in botany are down 50 % and advanced degrees in botany are down 41 % since 1988, when 72 % of the top universities offered advanced degree programs in botany. At the same time, undergraduate degrees in general biology have increased 17 % and advanced degrees have increased by 11 % (NCES 2009, taken from Kramer et al. 2010; Fig. 1.2).

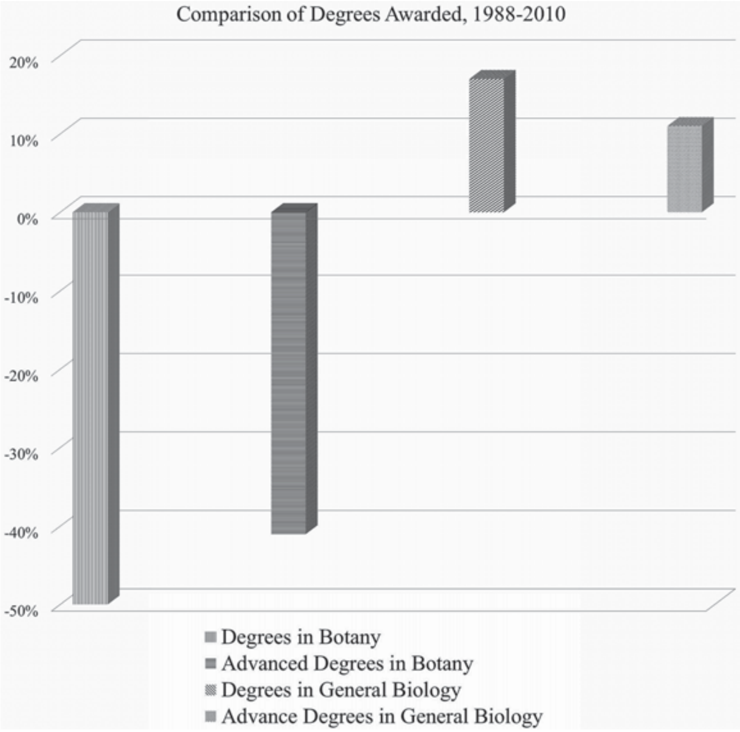

Fig. 1.2 Comparison of botany and biology degrees awarded from 1988 to 2010

1.2.3.1 Decline in Botanical Course Offerings

More than half of these universities have eliminated their botany and related plant science programs. Universities are removing a range of plant science courses, with botany and plant anatomy at the top of the list. Of the 400 faculty surveyed, 40 % responded that plant science courses had been eliminated within the last 5–10 years, and 51 % were not satisfied with the selection of plant science courses offered at their university (Kramer et al. 2010).

1.2.3.2 Preparation for Employment at Federal Agencies

Due to the elimination of botany courses in universities, students considering careers as botanists in federal jobs have difficulty obtaining the training they need to qualify for jobs that, in most cases, require 24 h of college credit courses in botany. To compound the problem, faculty retirement will even further impact courses available within the next decade. Survey respondents indicate that 35 % of all academic respondents and 40 % of all government sector respondents will retire within the next decade (Kramer et al. 2010). There will be a significant need for workforce training and education to fill botanist positions in order to meet the grand challenges.

1.2.4 How Are Universities Preparing Students for a Career Pathway to Fill These Jobs?

The bottom line for the Botanical Capacity Assessment Project is that "Botany is not optional" (Kramer et al. 2010). Yet, the question is how universities will prepare students with the skills necessary to address global challenges? In an article, "Perceptions of Strengths and Deficiencies: Disconnects Between Graduate Students and Prospective Employers" (Sundberg et al. 2011), the data show university students' view of their greatest strengths were in areas that potential employers viewed as their greatest need for improvement. Written communication skills got the lowest ranking among employers (and the highest among students), with ecological skills, field skills, plant identification skills, and botany ranking high as areas that needed the most improvement. The survey shows that skills in problem solving is not where it should be after two decades of a focus on "doing science" to develop critical thinking and problem solving. The concern from this study lies in the fact that employers say that they do not have enough botanically trained staff to meet their current management needs, while at the same time botany departments are being merged into biology departments and plant science courses are not available or are in the process of being phased out. They conclude with the plea for all stakeholders in the education process to "make clear to educational institutions their expectations about graduates" (Sundberg et al. 2011). Universities must prepare students to fill the pipeline for jobs that require trained scientists who have the field skills, communication skills, and critical thinking skills required to implement new strategies for dealing with loss of biodiversity and the threats of climate change on the health and well-being of humans and the environment (Sundberg et al. 2011).

The field of biology has taken steps towards solving this dilemma. In 2009, a call for action for change in biology education sparked a series of stakeholder conversations about the need to ensure that "all students graduate from college with a basic understanding of biology" (Brewer and Smith 2011). From these conversations and professional meetings, a landmark document, the *Vision and Change in Undergraduate Biology Education: A Call to Action,* was published in 2011 by the American Academy for the Advancement of Science (AAAS) and funded by the National Science Foundation (NSF). Authors described the "daunting challenge" in transforming deeply embedded academic traditions of instruction to new strategies that align with what educational research shows about how learning takes place (Brewer and Smith 2011).

Recommendations for "change" are to (1) integrate core concepts and competencies throughout the curriculum, (2) focus on student-centered learning, (3) promote a campus-wide commitment to change, and (4) engage the biology community in the implementation of change. The "call to action" to the biology education community is for all those who teach to "develop a coordinated and sustainable plan for implementing sound principles of teaching and learning to improve the quality of undergraduate biology education nationwide." It stressed that all biologists should be involved since the "stakes are so high" (Brewer and Smith 2011).

1.2.5 What Role Does Ethnobiology Play in Contributing to the Pipeline and Filling These Gaps?

Change can be difficult in a field with deep roots in traditional university pedagogy that has been in practice for centuries. As an example, biology remains focused on understanding life; however, it is undergoing "tremendous transformation as many new discoveries are being found at the intersection of biology and other disciplines" (Brewer and Smith 2011. Fields such as biochemistry, bioinformatics, and systems biology are changing the way we think and are solving problems that would not be possible through the focused lens of biology. These new perspectives are also changing the way we do research. In a quote from the *Vision and Change* document, the author says, "These new integrated fields, spread across the diversity of life sciences, are opening up a vast array of practical applications, ranging from new medical approaches, to alternative sources of energy, to new theoretical understandings based in the behavioral and social sciences" (Brewer and Smith 2011).

This is mirrored in botanical science. A survey of North American schools of Botany, Biology, and related fields in 1996 looked at the educational trends in economic and ethnobotany and determined that the field has grown "at a rapid pace since the 1960's" (McClatchey et al. 1999). The survey sought to produce a summary of the programs available for perspective students and to encourage advancement of programs through the sharing of institutional information that could help develop new programs. Results indicated that while there were fewer courses being taught, the courses offered had a greater depth and breadth of content, and attracted a greater diversity of students, with more seeking general science, education, and social sciences, instead of primarily botany. A shift in focus from a strictly economic botany field was beginning to take shape as student interest broadened from general use of plants by people to cultural diversity and the cultural uses of plants, ethnoecology, and cultural conservation (McClatchey et al. 1999).

A recent survey (OSN 2012; Chap. 3 of this volume) by members of the Open Science Network (OSN) reported some of the same issues that were documented in the 1996 survey. Concerns continue about lack of funding for programs, a need to improve the integrity and academic rigor of the discipline so that it could be considered a more credible discipline by the academic community, and the need for pedagogical enhancement and professional development.

Ethnobiology is seeding a revolution in education. It plays an ever-increasing role in filling the gap as traditional botany courses are being taken from the course catalogs and more ethnobotany courses are being offered around the USA. A national conversation, fueled by a revolution taking place in the biological sciences, is magnifying the need for change in the way we are preparing students to work and contribute in a rapidly changing scientific and technological society. The emerging field of ethnobiology education is positioned and ready to lead the way for change in the way students learn and in how they gain a better understanding of the nature of science.

1.2.5.1 Why Ethnobiology?

Ethnobiology Is Relevant It engages people where they are in life. Dr. Sunshine Brosi, a leading educator in a US ethnobotany program at Frostburg State University, Maryland, described ethnobiology as the "connector piece to science." It connects her students to nature in their place and gives them a way to connect to their cultural heritage through traditional ecological knowledge.

Individuals need to know the plants that provide for their daily needs. A study conducted by Dr. Gail Wagner at the University of South Carolina asked 31 college students to free list plants. Learning what came from that study reinforced the difference direct versus indirect experiences in nature can have on knowledge of plants. It also indicated that the plants most often known are those that are culturally salient to the individual, not necessarily those that are native to the region. In order for young people to even notice and attach meaning, they need to be able to relate personally to that plant (Wagner 2008).

Ethnobiology Is a Bridge It allows instructors to bridge interest and encourage involvement of students from a wide variety of ethnicities and academic backgrounds (McClatchey et al. 2013). Leading educator/researchers, Dr. Will McClatchey and Dr. Kim Bridges, formerly at the University of Hawai'i at Manoa, used ethnobotany as a bridge to science in an introductory undergraduate course. Segues to Science introduced students to diverse fields of science through the study of plants used by people. For example, students learned about the chemistry of plant-based beverages through an exploratory activity with plants.

In a 2005 report, Bennett described ethnobotany and ethnobiology as natural links to conservation biology, resource management, and environmental education. He argued that ethnobotany should include all plant and people interactions and not be restricted to traditional cultures (Bennett 2005).

A recent article implies that ethnobiology is the "missing link in ecology and evolution." It argues that since ethnobiologists have a better understanding of the relationship of humans and nature, they are better equipped to apply local knowledge in ecological and evolutionary biology research (Saslis-Lagoudakis and Clarke 2013).

Ethnobiology Is Interdisciplinary Combined research efforts and shared knowledge across disciplines is being encouraged by funding agencies worldwide. Ethnobiology is the study of the interaction of "biota with human cultures" (McClatchey et al. 2013), richly interwoven with the fields of botany, biology, ecology, sociology, cultural anthropology, economics, and others.

Ethnobiology Promotes Twenty-First Century Thinking Its multidisciplinary nature invites diverse perspectives that encourage growth in critical thinking skills among students. It utilizes multimedia and technology, and it places the responsibility for learning on students, as instructors become facilitators. Examples of this are the digital storytelling videos produced by Gail Wagner's classes at the University of South Carolina (see the Knowing Nature Project YouTube Channel).

Ethnobiology Retains Students in STEM Fields The president has called for an increase in the number of STEM graduates by 34 % in the next decade. In the USA, the retention of students in STEM majors is less than 40 % of those who enter college in STEM fields (White House 2009). To meet the need for 1 million additional job candidates over the next decade, we must retain those who begin the pathway. The interdisciplinary nature of ethnobiology, with its naturalistic view and local reference, makes it an excellent pathway for retention of students in all STEM majors (McClatchey et al. 2013).

Ethnobiology Is Active McClatchey relates the term "biophilia" to ethnobiology as the study of human interactions with their biological world, indicating that we as humans are innately drawn to experience the natural world (McClatchey et al. 2013). Studies have shown that active engagement with nature has positive effects on human development (Kellert 2002). All learners benefit from active learning through multisensory experiences that cannot be experienced virtually. Best practices in ethnobiology include field studies for students to learn about useful plants in their habitat and to apply scientific and technology skills. An example is the long-running University of Hawai'i at Manoa Field School program.

Ethnobiology Fits the Budget Teaching materials are everywhere. The use of local plants is usually free, and these plants can be used to involve local naturalists who can share cultural reinforcement between younger and older generations. Using local plants creates more frequent reminders of ethnobotany lessons and can stimulate an interest in learning more about one's place (McClatchey et al. 1996).

Ethnobiology Is Ethically Grounded It aligns with the principles laid out by the *Vision and Change* document which calls for courses to begin "integrating social, environmental, and ethical considerations into the teaching of biology" (Brewer and Smith 2011). The first strategy developed by the OSN for Ethnobiology was a statement of ethics in the outline for philosophies of the project (Wagner 2009). It states that ethical conduct is a "vital facet to conducting research, research that deals with human subjects, human knowledge, and land."

Ethnobiology Is a Key to Survival Ethnobiology and its related discipline ethnobotany are vital to a sustainable relationship with earth and its resources. According to the Kaua'i Declaration, ethnobotany can strengthen our connection to the natural world. "It is of central importance for understanding the collective experience of humankind in a series of exceedingly diverse environments and using those experiences to meet the challenges that we face. It makes it possible for us to learn from the past and from the diverse approaches to plants represent by the different human cultures that exist today. Ethnobotany is at once a vital key to preserving the diversity of plants as well as to understanding and interpreting the knowledge by which we are, and will be, enabled to deal with them effectively and sustainably throughout the world. Thus, ethnobotany is the science of survival" (Prance 2007).

1.2.6 Ethnobiology Curricula and the Open Science Network

Unfortunately, ethnobiology curriculum is not readily available. The problem lies in the fact that peer-reviewed ethnobiology and ethnobotany teaching resources have not been easy to access. In response to a growing demand for curriculum and resources for ethnobiology classes, the OSN was formed to bring together a community of like-minded educators to share curriculum and to improve their practice. The OSN shares peer-reviewed educational ethnobiological materials on an open, web-based platform. Funded by a NSF grant in 2008, the OSN has grown its membership and its reach to the majority of colleges and universities that teach ethnobiology courses in the USA and Canada.

As participants in the OSN charged with peer-reviewing materials for the curriculum repository discovered, the field of ethnobiology lacked curriculum standards on which to base their review. Undergraduate educators wanting to create new courses for their institutions were in need of both curriculum and course recommendations. In its fourth year of an RCN-UBE grant from the NSF, members organized a working group in November 2011, and again in February 2012, to consider trends in ethnobiology education and to prepare the groundwork for course and curriculum recommendations and voluntary program accreditation standards for ethnobotany taught at the university level. Invited participants represented both past OSN participants and university ethnobiology instructors not previously involved in OSN meetings. Teams made up of educators from 27 US and Canadian universities, one European institution, and 34 professional societies, representing the Society for Economic Botany Education Committee, the Society of Ethnobiology (SoE), the International Society of Ethnobiology (ISE), the AAAS, the NSF, the National Science Teachers Association (NSTA), and others, met to create consensus on ethnobiology literacy standards (McClatchey et al. 2013).

The discussions that pursued were guided by the *Vision and Change in Undergraduate Biology Education* document challenging educators to facilitate more student-centered learning in their classrooms. In the landmark document by Brewer and Smith, the curriculum model that resulted from this work emphasized development of learning outcomes, core concepts, and competencies for scientific literacy. All of these are to be achieved through measurable training goals and use of effective teaching strategies. The plan calls for not only student assessment, but also assessment of the curriculum and instructors (McClatchey et al. 2013).

The OSN working groups proposed a draft parallel document to the *Vision and Change* mandate as a framework for discussion and development of ethnobiology undergraduate education within the USA (McClatchey et al. 2013). The ethnobiology program hallmarks identified core concepts and competencies for ethnobiology literacy. Core concepts are the central ideas upon which the study is developed. Brewer and Smith (2011) identified four biology core concepts: (1) structure and function; (2) information flow, exchange, and storage; (3) pathways and transformation of energy and matter; and (4) systems. The OSN modified the original concepts to better include humans and social systems as part of nature, rather than

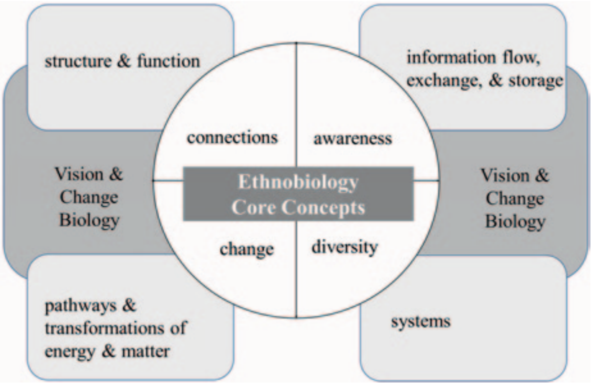

Fig. 1.3 The Open Science Network proposes a modified approach to the *Vision and Change for Undergraduate Biology* core concepts to include humans and social systems. Four additional interdisciplinary concepts are suggested: connections, awareness, change, and diversity

separate from nature. OSN then proposed four additional concepts that highlight the interdisciplinary nature of ethnobiology. They are (1) awareness, (2) diversity, (3) change, and (4) connections (McClatchey et al. 2013; Fig. 1.3).

Learning outcomes are another central feature of the recommendations, in line with the new emphasis on twenty-first century strategies for students. Learning outcomes describe what the learners should be able to do or know. They encompass the core concepts and competencies for ethnobiology education. Within the core concepts, six broad categories of learning outcomes were identified for ethnobiology education: (1) interactions of organisms and environments, (2) specialized knowledge of specific organismal groups, (3) multiple cultural perspectives, (4) research languages, (5) problem-solving skills, and (6) professional skills. Examples of specific areas are given for each outcome (McClatchey et al. 2013).

Another key element of the curriculum is to have a strategy to measure the program's success. These are objectives that can be assessed that measure the effectiveness of the program in producing desired outcomes. An example of an appropriate assessment might be that a fraction of the learners graduating from the program (1) obtain a job, (2) obtain a job using skills learned in the program, or (3) obtain a job in one of the program-targeted work areas. These apply for both courses and degree programs (McClatchey et al. 2013).

Central to the recommendations are teaching and assessment strategies that are effective in achievive goals. Based on the twenty-first century thinking, instructors need to embrace alternative teaching strategies that promote active, student-centered learning that integrates real research opportunities as much as possible. Assessment of degrees, concentrations, courses, or other levels of organization are essential for development of ethnobiology programs. In addition to the formative, summative, and process assessment, a program must also assess individual learners (McClatchey et al. 2013).

Critical to the process are instructor and institutional qualities. These are measured in relationship to student achievement and success in achieving program hallmarks. Instructors are to be facilitators of learning, not sources of knowledge. The OSN recommends that instructors obtain continuing education training such as that established by the OSN. The network offers annual workshops at society meetings and conferences, such as the Life Discovery Conference.

The work of the OSN project focused on establishing preliminary outlines for an Introductory Ethnobiology course, Medical Ethnobotany, and an Advanced Ethnobiology course. Working groups also established preliminary objectives for ethnobiology degree programs, including draft recommendations for undergraduate major and minor degree plans in ethnobiology, guidelines for a Certificate in Ethnobiology, and programs for both science and social science majors who want to concentrate in ethnobiology.

The *Vision and Change for Ethnobiology Education* (available on the OSN website: http://www.opensciencenetwork.net/) is intended to start a long-term conversation about best practices for ethnobiology literacy. More discussions are needed to advance the field and develop more course outlines for ethnobiology education (McClatchey et al. 2013).

The Society for Economic Botany (SEB) has taken a leadership role in the development of ethnobiology education among other professional societies through the OSN for ethnobiology and its *Vision and Change* document. The SEB and its sister societies, the SoE and the ISE, have included the OSN for ethnobiology as an education initiative for their organizations. Post-grant funding, the OSN has adopted a governance charter and is a self-sustaining entity with plans for continuing the support for ethnobiology education.

1.2.6.1 Nonformal Education

Outside of academia, there are a number of successful projects that increase awareness and knowledge of the plant world. Professional societies and nonformal education providers play an ever-increasing role in botanical education (Kramer et al. 2010). The Botanical Society of America (BSA) is a leading society for botany education in the USA. BSA provides support for botany careers and is the clearing house for botany jobs. In addition, it brings professional societies together to create rich educational resources. An example is the online resource EcoEd Digital Library (EcoEdDL), a forum for scientists and educators to find and contribute peer-reviewed educational resources (http://ecoed.esa.org/). This project is the result of collaboration between the Ecological Society of America, the Society for the Study of Evolution, the SEB, and the BSA and is supported by the NSF. In addition, the BSA partnered with the SEB to host the Life Discovery Conference as a forum to bring educators together as a professional learning community to share best practices in biology education.

1.2.7 How Are We Filling the Gaps at the K-12 Level?

No one will dispute the importance of improving our efforts on the university level in training our future workforce. The question is whether our target audience should be even younger. Universities must complete the pathway for students, but K-12 schools must create the pathway and produce students who choose to prepare for careers in the botanical and environmental sciences. Both formal and informal education, nonprofits and professional societies have the opportunity and the mandate to do things the schools cannot do. This can be achieved through a number of different paths, examples of which are described below.

1.2.7.1 Public Engagement

Botanic gardens and botanical science centers are the primary centers for learning about the value of plants in our lives. An example is the live exhibit for plants useful to people at the National Botanical Garden in Washington, D.C. Public engagement is critical for keeping plants in the foreground of public awareness.

1.2.7.2 Youth Programs

Many middle and high schools are now challenging students to pick a pathway towards a career and attend schools with a curriculum that emphasizes the skills and knowledge students need to achieve in that field of study. One of the largest urban school districts in the nation, Fort Worth ISD does not currently offer a school of choice with a focus on the environment, much less botany or ethnobiology.

There are, however, well developed curricula for high school students and teachers through New York Botanic Garden's (NYBG) Plants to People program. The first curriculum guide, "Cultural uses of Plants: A Guide to Learning about Ethnobotany" has been in use since 2000. A more recent publication from NYBG is "Ethnobotany Explorers," an ethnobotany program for grades 9–12. Aligned with national science and STEM standards, the program is designed to supplement high school life science curriculum with active, inquiry-based learning that involves students in projects from "exploring the traditional uses of plants (such as dye making and cooking) to researching the medicinal properties of plants." The program is available for teachers through NYBG website and on DVDs that "serve as a window to the world of ethnobotany research and gives students a look at ethnobotany in action."

Other programs deeply embedded into the culture and traditions of rural America are the 4-H and Future Farmers of America youth programs. These community-based programs engage young people in learning about agriculture through service-oriented, project-based learning. As part of their learning, children and youth learn about the plants on their farms and ranches and identify those that are both beneficial and harmful to livestock and people. In Texas, one of the state's leading agriculture programs, Texas A&M University, has developed a program that challenges students to identify and describe attributes of plants on their farms. Each year, students gather at stock shows across the state and compete in a Plant ID contest for scholarships. The Botanical Research Institute of Texas (BRIT) supports this program through its plant collections and has developed a technology tool that allows students to not only identify plants and their uses, but to also practice their skills for the contest. The app is available for cell phones (Fig. 1.4).

Fig. 1.4 The BRIT Guide to Texas Range and Pasture Plants is available as a cell phone application at http://www.brit.org/

1.2.7.3 "*PlantingScience*" Project

A program that has led the way for authentic research experiences for youth is the PlantingScience project developed by the BSA. The BSA, in collaboration with 14 professional science societies, including the SEB, responded to a call from the national academies to become leaders in supporting inquiry-based STEM education, the BSA and 14 partnering societies developed PlantingScience, a web-based mentoring program for middle school, high school, and college students. Students work in teams with practicing scientists and are allowed time to develop their own questions, using module themes accessible online. Students and mentors work through a 3–10-week project all online, which allows scientists from any part of the world to be accessible to the classroom whenever they meet. The goal is to be able to support a capacity of **250,000+ students per year.**

1.2.7.4 Nonformal Education at the Botanical Research Institute of Texas

The BRIT is a nonprofit conservation organization committed to research and education. BRIT's mission is to "conserve our natural heritage by deepening our knowledge of the plant world and achieving public understanding of the value plants bring to life." Currently, the organization is investing its institutional resources into a collaborative effort between BRIT research and education programs in order to engage the public in science through locally relevant, highly visible issues. BRIT uses a place-based focus to promote inquiry-driven exploratory learning.

BRIT's research and education teams have combined forces on a pilot project for middle and high school youth from inner-city neighborhoods and the lowest performing schools in the state. Based on the successful Field School from the University of Hawai‘i, the BRIT Field School is designed to equip students with field science and technology skills and to promote leadership in a setting that challenges them to investigate their local ecology. As part of their experience, students were taken on a field expedition to the Texas Gulf Coast, far away from the poor urban neighborhoods in which the students live. Teachers have documented remarkable change in their attitudes about learning and their participation in class as a result of the field school experience. Not only had they conquered their fears and gained self-confidence, their perception of nature and their interest in it changed significantly as well. Key to the success of the program was providing authentic experiences for these young people. Doing "real science" with "real scientists" gave them the opportunity to observe how scientists think, how they observe, and how they collect and analyze data. Their science mentors are seen as real people who are passionate about their work and committed to learning more.

Pre-K–Grade 5 Education One can argue that plant science education should begin even earlier. Brain-based research indicates the pathway begins in early childhood as children develop a natural intelligence through direct contact with nature. Richard Louv brought national attention to the phenomena he described as "nature-deficit disorder" (Louv 2006). Children who do not have those direct experiences in nature suffer negative effects on their health, their happiness, and their academic performance.

BRIT embraces that philosophy and provides outdoor experiential learning for children designed for learning about their place, an educational term that means the components of their local region. A place-based approach to learning includes not only the local ecology of a place, but also its culture and community. Ethnobiology strongly supports place-based learning as people explore the biological components in context of the human and cultural influences of that place.

BRIT provides a number of programs designed to initiate enchantment with their place. Camp BRIT and school field trips introduce young learners to the geological and biological history of their place from the perspective of the past, the present, and the future. They learn about early people who made the prairie their home and depended on plants for their existence: They learn how the prairie shaped our culture. They learn about the soils, the plants, and the wildlife that inhabit a native prairie ecosystem in an urban setting in the middle of the cultural district of Fort Worth, Texas. Middle school students work along scientists at BRIT. They explore the plant world and their native environment, ask questions, contribute to "real" research, and propose ideas on using plants to create a more sustainable world of their future.

The common thread with programs for K-12 students is authentic experiences that build on one's knowledge of their place: their natural environment, their culture, and their community. These experiences fuel their curiosity and guide their interests about plants in their world.

1.3 Conclusion

In conclusion, we must continue to build ethnobotany into a rigorous, credible discipline that will attract the brightest and most passionate plant advocates while supplying the world with professionals who can intelligently address global environmental concerns. However, we must also support educators in building curriculum resources suitable for twenty-first century learners in K-12 schools to capture young minds as they begin the career pathway.

In an interview of the BSA leadership, Bill Dahl and Claire Hemingway defined the key issues in botanical education in the USA. While there are many worthwhile programs being delivered, greater impact could be achieved if programs were more collaborative and worked together to achieve educational goals. For the programs that are working, the problem is in sustaining efforts over time. Funding from both foundations and corporations continues to be problematic. Those that do survive contribute to increasing botanical capacity, but there is not a current alignment to show how collectively they contribute to the pathway to careers.

The gap is the absence of a vertical integration of botanical education from K-12 to higher education. The strategy is collaboration. If we work together to achieve integration of botanical education from K-12 to higher education to careers, we can create the pathway people need to become more effective in carrying knowledge of plants forward in the USA to meet the challenges ahead.

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Chapter 2
Lessons Learned in Development of an Interdisciplinary Science Curriculum Support Organization

Will McClatchey and K. W. Bridges

2.1 Background

In 2007, a group of scientists were discussing two problems that all were encountering in development of interdisciplinary undergraduate curriculum. (Curriculum as used here refers to all course content within a program of study leading towards understanding of a specific subject. This could be the content of one course or an articulated set of courses.) First, there were numerous interdisciplinary scientific societies, yet none focused on an interdisciplinary science curriculum. Second, there was no organized structure for accumulation, assessment, and distribution of curriculum content and teaching experiences outside of specialized disciplinary journals and numerous science education societies with different agendas. The Open Science Network (OSN) was created as a response to study and implementation of an interdisciplinary, intersocietal (formed from members of several societies), interinstitutional (formed with members of many institutions), open-access group that would exchange curriculum materials (discrete parts of which we call modules). The network was constructed by social and natural scientists working in the areas of ethnobiology or more broadly, conservation biology. Funding was obtained to promote a variety of OSN activities. A number of lessons were learned during the first 5 years (~2008–2012) of OSN's existence. We believe that these lessons may contribute to the development of similar interdisciplinary educational support organizations. Here we present the strengths and weaknesses of the process that is now emerging into its next phase. We begin with some background and then plunge into some of the more important lessons.

W. McClatchey (✉)
Department of Research, Botanical Research Institute of Texas,
1700 University, Fort Worth, TX 76107, USA
e-mail: wmcclatchey@brit.org

K. W. Bridges
Botany Department, University of Hawai'i at Manoa, Honolulu, HI, USA

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2.1.1 Development of an Idea

Instruction is generally a significant part of an academic's responsibility. Courses are developed, often in the instructor's area of academic interest, and merged into a curriculum. Creating a good course is hard work. Topics need to be chosen and then developed into instructional activities, whether these are lectures, discussions, or laboratory exercises. Developers of each course need to recognize the existence of other instructional activities so that there is an appropriate mix of new materials and reinforcement of previously learned topics. The result is often a set of courses that have tight integration.

The initial members of the OSN included instructors in two of three US programs offering degrees in ethnobiology, University of Hawai'i and Frostburg State University.

The instructional staff in the Botany Department at the University of Hawai'i at Manoa (UHM) developed a set of courses that met the requirements for a Bachelor of Science Degree in Ethnobotany at UHM, as well as graduate courses that supported MS and PhD level students in Ethnobotany. These were coordinated with instructors of ethnobiology courses at University of Hawai'i at Hilo, and the network of Hawai'i Community Colleges. Frostburg State University in Maryland developed a program using UHM as an initial model. This history led to discussions, both internally and with colleagues from other institutions, about sharing curriculum materials.

The first steps toward sharing happened with a course offered as an Introduction to Ethnobotany (BOT 105). This is a popular course on the UHM campus with hundreds of students enrolling each time it is offered. The instructors were able to obtain an intramural grant through a competitive campus program to modify this course's style of presentation. Initially, all lectures were produced in a video format so that students could watch them multiple times and asynchronously. Most often, the video production was done at an off-campus location that was appropriate to the subject matter (e.g., discussions of food were done in a restaurant). This course "rebuild" involved other innovations that allowed more faculty–student contact than the traditional lecture format, such as smaller discussion groups with the instructor to review content from video lectures. The important point here, however, is that there were a number of video "modules" produced for this course. These could be distributed at little or no cost to faculty members at other institutions. We saw this as a considerable benefit as we envisioned other faculty members being able to choose a relevant set of the UHM materials and integrating them into their courses. This would save the non-UHM faculty members time and add value to the UHM production effort.

We asked ourselves the simple pair of questions: Will this work for this introductory course? Can it be generalized to a larger system of exchange within the discipline of ethnobiology?

2.1.2 The Internet Provides a Key Medium of Exchange

The experience of distributing BOT 105 video materials taught us some lessons. In the early years of using this video-based system, the video materials were available either online or as a set of DVDs. The online versions were often difficult to use as CODEC standardization was not common. Furthermore, the storage of the materials was difficult (due to the then high cost of online storage) and streaming rates limited access for many students. Producing sets of DVDs was also very tedious, even when we used a robot DVD duplicator.

The development of the Internet at that time was promoting the concept of open-source materials. We saw this as a key concept underlying all of our curriculum and distribution efforts. "Open" rapidly became our "mantra," and we set about developing a system in which every ethnobiology instructor could share materials, teaching strategies, and curricula.

The mechanism for sharing would be the development of a set of articulated webpages. On these pages instructors could post links to their resources, as well as find materials that had been made available by faculty members from other institutions. Note that the intent was not to store materials, but to provide access to items through links. All materials would be kept on the originating institution's web servers.

Several different platforms (e.g., WiserEarth, Facebook, Google sites, and university servers) were tried as hubs for our activities and at one point these were all linked to each other. This proved to be both complicated and confusing. A decision was eventually reached to produce a simple, single entry point with consistently formatted links to content in many different locations.

2.1.3 Funding the Open Science Network in Ethnobiology

A draft proposal was developed to fund the basic requirements of a collaboration across the broad spectrum of ethnobiology instructors. We recognized that the University of Hawai'i might not be the best locus for this effort—in part because of the geographic isolation but more important, we felt that a more "neutral" institution would better support a collaborative effort. After much discussion, a decision was made to aim for an "open society" model with no academic institution being the owner of the collaborative efforts of the group. This was seen as being parallel to the concept of "open access." Pat Harrison and the Botanical Research Institute of Texas (BRIT) agreed to sponsor this effort and the proposal was modified to add the skills and interests of BRIT and its staff. The proposal was funded by the US National Science Foundation (NSF) as part of the Research Cooperative Networks program. The OSN for ethnobiology then truly began.

One concern that was addressed early in the process of developing the concept of "open society" collaboration was a decision about which of the "Ethnobiology" societies (e.g., International Society of Ethnobiology (ICE), Society for Economic Botany (SEB), Society of Ethnobiology (SoE), Society of Ethnopharmacology

(ISE)) would serve as the home sponsor of the OSN. Consistent with the open society concept, a decision was made to include all of the societies and to have none (or all) of them serve as the home. However, the societies varied in their interest in providing time and resources for development of OSN.

Scientific societies are organized to bring specialists together to disseminate and discuss their activities. Usually, the presentations involve research. However, many scientific societies list educational aims as part of their charter. For example, the SEB states that its mission is to "foster and encourage scientific research, *education,* and related activities on the past, present, and future uses of plants, and the relationship between plants and people, and to make the results of such research available to the scientific community and the general public through meetings and publications" (SEB Website, http://www.econbot.org/). However in reality, there was little discussion on education topics at annual SEB symposia and workshops in the years before the OSN project started. This changed with the calling of the first OSN workshop at the 2008 SEB meeting at Duke University, North Carolina.

One of the major OSN goals was to create as large a network of ethnobiology educators as possible. OSN members actively participated in meetings of the allied ethnobiology societies at their meetings and brought the existence and goals of OSN to the attention of the various society councils and directors. This was aided by the often overlapping society memberships and governance roles of many OSN participants.

2.1.4 A Shifting Environment: The AAS and NSF Vision and Change Document

The American Association for Advancement of Science (AAS) and the NSF worked together with hundreds of college biology instructors to produce a landmark document, *Vision and Change in Undergraduate Biology Education* (Brewer and Smith 2011). Early drafts of this document were available in 2010, or about halfway through OSN's first 5 years. Several OSN participants had been part of the *Vision and Change* development process so the document came to OSN with both the impact of an insider's understanding of the educational issues as well as the leadership to promote the changes called for by *Vision and Change*. Simply put, *Vision and Change* challenged the traditional pedagogy and strongly encouraged instructors to (radically) revamp their methods. This was a call for change that involved more than a modification to the delivery of materials; it called for revisions to every phase of the educational process from planning to assessment.

The timing of this report was fortuitous. By 2010 OSN had established a network of over 200 participants with several annual meetings of 60–80 people. The project was becoming experienced in holding educationally based workshops. There were funds remaining in the grant to hold additional workshops to fully explore the implications of *Vision and Change* on ethnobiology. There were also opportunities to more deeply involve scientific societies, such as SEB, in the process of educational change.

The importance of the *Vision and Change* document cannot be overestimated in the ultimate success of the OSN.

2.2 Lessons Learned

We feel that other disciplines may be facing the same opportunities and challenges that created the OSN and guided its activities. We offer the following "lessons" as a way to build on our experiences.

2.2.1 "Little Red Hen" Effect

"The Little Red Hen" is a Russian folktale in which one individual identifies a resource and then proceeds to ask others to help in its development. No one helps until it is time to reap the benefits of the added value invested. Then everyone previously invited to participate wishes to receive some of the benefit.

Just like the "Little Red Hen," we found that when we tried to bring together curriculum content, few are willing to contribute. However, virtually everyone appeared to be eager to tap into any value added by others. This asymmetrical relationship is not new in science. Most scientists are quite open to being critical of the work of other people and eager to seize on new results. Yet these same people are generally unwilling to present their own efforts for criticism. It is important to realize that this is a natural human response (although it is scientifically irrational). We were fortunate to find some "early investors" who were willing to take a chance by sharing their work. However, we seriously underestimated the importance of the "Little Red Hen" effect.

2.2.2 "Safe Harbor" Information Exchange

Development of an environment in which participants feel that they can safely share their work, especially preliminary ideas, is difficult but important for the process to advance. A safe harbor is an exchange location where curriculum may either be shared anonymously, or shared with credit and limited concern for abusive critiques.

The early phases of the OSN project included a desire to peer review all materials on the OSN website links. A number of reviews were obtained. Some were done by experienced faculty members who were familiar with both the discipline and the demands of the classroom. Other reviews were done by students, some of whom were truly novices in their experience in this discipline. The results were predictable and the peer review generally failed to accomplish its goal. It also established a barrier that likely discouraged further contribution of materials.

2.2.3 Trough Feeding

The OSN meetings, such as workshops, generally involved considerable travel as participants are dispersed widely across the country (and around the world). A small, loyal crowd agreed to invest their own resources in order to participate (paying their own travel, lodging, meals, etc.). Most participants, however, indicated that without funding support, they would not be able to attend the meeting.

We found that when funding is offered, there are very few people who are unwilling to participate in meetings. Time, at least for a 1- or 2-day meeting, is something they are willing to contribute. While it is likely that some researchers cannot afford the cost of participation, it is also likely that most can. For us, it is a question of people making the OSN activity a high enough priority. This process, of course, is the same as that observed in how faculty members fund their own research. Some will not conduct research unless all of the costs are covered and see little benefit in the investment of their personal resources.

We believed that more educators would be attracted by the benefits of working together with colleagues. Our original view was that there would be a large potential benefit gained from collaboration. We thought that most educators would see the cost in attending a meeting as a small expense relative to the benefits obtained through sharing. Although for some people this was true, for most, we were wrong.

Our experience was negative regarding the willingness to collaborate. We are not discouraged by this as the expansion in the types of mechanisms for sharing (e.g., online conferences) may reduce some of the need for expensive travel.

2.2.4 Learning Objectives and Assessment

Most instructors are familiar with learning objectives and many faculty members produce a list of these objectives for each course. In general, these learning objectives provide statements to the students regarding the sort of materials that will be covered in the course. The new pedagogical requirement for learning objectives is that each one is framed in a way that it can be measured. That is the basis of assessment. It is increasingly evident that this combination of learning objectives and assessments is going to be a widely used element in all courses. We have found both a poor understanding of the need for such a measurement system and difficulty in producing course materials that handle it adequately. This was unexpected. Science researchers are accustomed to presenting their research efforts with testable hypotheses and then conducting analyses of the results. Why should we be surprised that a course ought to be approached with the same logical rigor and be so feeble at, and even averse to, implementing such a system in the classroom?

Fig. 2.1 University of Hawai'i ethnobiology students learning about plant chemistry through hands-on learning, using taste analysis of fractions of beverage suspensions and colloidal mixtures

We thought that the OSN workshop participants would welcome discussions about learning objectives and assessment. These topics, however, were rarely addressed. We feel that this was a significant opportunity that was missed.

2.2.5 Learning Models

The lecture, although now mostly converted to digital presentations, is still the most common core strategy for learning within university courses. (Note that it also is still a common mode for presentation of new research at scientific meetings.) This is surprising given all of the publications that show other models as being more effective. The problem is an evolutionary one. Instructors are largely drawn from the ranks of those who were able to learn "effectively" through lectures, and these instructors can remember certain mentors who were "excellent lecturers" and therefore the idealized model is that of a lecture. This nonscientific thinking persists within the ranks of instructors and is not even often challenged by administrators, who should have an interest in promoting better forms of instruction.

The culture of scientific instruction needs to be challenged to change through the processes of (1) creating experiments with known methods and alternatives, and (2) regularly considering new published literature on learning models and teaching methods. The lesson we have learned is that most "scientists" are very unscientific in their approach to instruction and this results in less-than-optimal instruction. As an unintended consequence, we suspect that students may be learning through observation of instructor behaviors that scientists do not consistently approach decisions following scientific logic.

Much of the time invested in the last few OSN workshops was devoted to discussions of alternative course delivery systems, including hands-on experience in a number of alternative systems (Fig. 2.1). Educators had a chance to become the students again. Workshops were also held which focused on technology skills. These gatherings were designed to help faculty members who might have otherwise been reluctant to use alternative instructional methodologies.

2.2.6 Sharing

A number of scholars have shared their curricula using the OSN website. Sometimes this has just consisted of syllabi, but sometimes it has included course notes, videos, exams, and everything used to produce an entire course. The most common way that materials have been shared is through course websites that include content already accessible online. In a few cases, specific new webpages with content were developed, but this was not common as it appears few people want to invest time in something that will not yield a direct return for themselves or their students.

The problem runs deep. In essence, we have failed to develop appropriate ways to share educational resources. Contrast this to research. We publish our research so that it is widely available; in return, we get the academic equivalent of money—a publication for our vita. Tenure and promotion committees count the publications (at least at most institutions) and the more on the list, the higher the value. There is no widespread parallel for sharing educational materials. Our failure to create a system in which this kind of sharing is recognized will perpetuate our current system of not valuing educational collaboration. We will continue to deny ourselves, and our students, the benefits of working together.

The mechanisms for sharing surround us. We can produce a wide variety of Internet-accessible content. OSN participants have begun to publish course materials through peer-reviewed journals, but we have yet to see how this is accepted (or not) by tenure and promotion committees in the American academy.

2.2.7 Technical Competence

The varied level of technical skills of the OSN participants has impacted the project in several ways. The OSN project started at a time when some of the faculty participants were able to create and maintain websites. This was evident from a survey of course materials on university-based websites. Many webpages showed considerable sophistication and were frequently updated while many other websites were fairly simple and obviously out of date. Webpage style varied, too.

The differences in the approach to webpage design and maintenance produced a variety of early problems. The "open" philosophy of the OSN led us to permit any participant, even faculty members who had just discovered us through the Internet, to post new materials on the OSN website. The results did not follow the style that had been established by the webpages that were developed at the start of the project. The style differences made site navigation difficult. The attempted solution was to have a few website editors control the appearance of the content. New or revised materials would be solicited, such as through email. In practice, few people suggested additions or modifications of webpages. This was not very successful.

The production of "modules" has been the other area in which technical skills have been an issue. The OSN project started about the time that video capture was becoming reasonably possible using inexpensive equipment (such as digital video cameras). This trend has, of course, continued, and it is now possible for an individual to use commonly available equipment to produce a short video segment that is an acceptable quality to share.

Recall that the OSN project began with a full set of "lecture equivalent" video modules. These units were difficult to produce. They required the use of professional-grade equipment, high-end editing workstations, and substantial technical skill.

There are many "then and now" contrasts. The early efforts were aimed primarily at one-for-one lecture substitution. Now, the aggregation of many short segments is the norm. The original lecture-length (usually 45–60 min) video presentations used television-quality presentations as the model (both in length and quality). The current standard is for a more spontaneous presentation. There is much less editing done on the short segments and it does not require specialized hardware and software. Distributing the segments is done by moving the materials to an online location with only a click or two. Many early problems, such as the choice of the encoding CODEC, have essentially disappeared.

The relative ease of current video production has not yet resulted in a large production of video modules. That is not surprising. Most faculty members have had little experience in using these new technologies. OSN workshops have started the process, and these efforts are expected to continue. But there is the fundamental problem of each faculty member conceptualizing how such modules can be used as a substitute or supplement for their existing curriculum materials.

2.2.8 Organizational Constraints, Membership Changes, and Opportunities

The original concept of the OSN project was that it would require little governance and only minimal staff effort. There were clear expectations, as described earlier, about participant contributions and people independently incorporating links to their materials on the webpages, that the OSN project would be extremely efficient (i.e., low overhead).

Increasingly, staff and administrative time was required to handle routine tasks ranging from web updating to arranging and financing meetings and workshops. At the same time, it is important to recognize that the OSN project found important new avenues for collaboration and there was sufficient institutional flexibility to organize these around the newly revealed challenges presented by *Vision and Change*. Specifically, there was an emergence of faculty from higher education institutions that are teaching oriented (not research intensive). This was a strong response and the people who attended the OSN workshops from community colleges and primarily undergraduate 4-year universities brought a renewed stimulus to the discussions of education. This change in focus was sufficiently strong that one of the recent workshops was held at a community college and faculty members from other community colleges in the same region were invited to participate.

Flexibility was required to make such a fundamental shift in the type of participant. This was not just an administrative (and financial) ability to incorporate the expanded set of collaborators. Equally important was the willingness of the OSN core participants, most of whom were from research-intensive universities, to welcome these new faculty members. It was soon apparent that these new participants, for whom teaching is a life mission, brought some important experiences and attitudes to the entire group. Moreover, it is likely that this teaching-oriented faculty will be the first to implement the changes suggested by *Vision and Change*.

2.3 Conclusion

2.3.1 Process Strengths and Weaknesses

Many aspects of the academic landscape changed during the first 5 years of the OSN project. Some we could predict. For example, it was clear that technology would evolve and become more helpful. Some changes were completely unexpected. The publication of the *Vision and Change* challenge is an example.

We feel that a strength of the project is that it is truly open. Some of our perspective is based on the ethical requirements of our scientific discipline. We respect intellectual property rights and have a strong ethic promoting the distribution of what we learn. As a result, we are not a group that collects and holds information. We are colleagues that simply want to share.

Our alignment with scientific societies, which we have actively created, is also an asset. For example, we now have a formal relationship with the SEB and the SoE. OSN will continue to promote education within the societies.

There are still weaknesses in the OSN. We did not get as many contributions of materials as we expected. The result is that the OSN repository of course modules is much too small. The last stage of OSN's first 5 years is attempting to remedy this situation. Workshop participants will be creating new modules so that there will be cadre of individuals who can advise and inspire other faculty members to take on the new challenges with the new technologies. The goal is to get a critical mass of high-quality modules. This will help make the OSN effort self sustaining.

2.3.2 Vision and Change in Ethnobiology

A challenge that was implicit within the *Vision and Change* document is for biologists (and other scientists) to develop content that really meets the needs of learners and does so using efficient learning methods. OSN participants have taken this to heart and over a series of six meetings they developed an ethnobiology version of the *Vision and Change* document—*Vision and Change for Undergraduate Ethnobiology Education in the USA: Recommended curriculum assessment guidelines* (McClatchey et al. 2013). This document was produced primarily to answer two questions that are common to emerging disciplines: What should we teach and how should we teach it? New instructors ask these questions and the answers, when involving the best science within the discipline, will help to advance not only the quality of education but also the quality of research generated by instructors and their students.

2.3.3 Transition into an Independent, Self-governed Support Organization

One of the original goals of the OSN project was that it would persist without external support. Funding from the NSF let us experiment with infrastructures, create strong links to a variety of scientific societies, and mobilize an active group of faculty members who are committed to strengthening the educational aspects of the discipline of ethnobiology.

The transition to an independent organization has begun with the establishment of bylaws and the election of the first set of officers under this new charter. We see that scientific societies are now scheduling significant blocks of time for presentations and workshops that are devoted to educational topics. The next generation of OSN will shoulder much of the responsibility for making sure that the focus of these new time allotments are filled with relevant participation. Keeping track of lessons learned and sharing them with a new generation of scholars will be one critical role that the OSN will continue to fulfill.

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Chapter 3
The Contribution of Ethnobiology to Teaching Plant Sciences: Student and Faculty Perspectives

Sofia A. Vougioukalou, Keri Barfield, Ryan D. Huish, Laura Shiels, Sunshine L. Brosi and Patricia Harrison

3.1 Introduction

Stimulating a broad interest in plant sciences for undergraduates can be a challenge for educators. During the last two decades in the UK and the USA, there has been a historic decline in the uptake of plant sciences and a sharp reduction in the number of universities offering degrees in botany (Drea 2011). Hershey (1996) notes that "botany neglect" is a long-standing problem in biological science teaching due to a biased emphasis on zoology. Potentially, ethnobiology could fill this gap. Ethnobiology—the study of relationships between peoples and the biotic factors in their environments—is a synergistic combination of disciplines that is drawing the interest of a growing number of students, and thus an increasing number of instructors and courses in academic institutions around the world. Core to ethnobiological research is demonstrating the inextricable link between biological and cultural diversity, and this is highlighted by the contributions of traditional knowledge to the conservation of biodiversity and the discovery of new drugs (Stepp et al. 2002; Cox and Balick 1997). Bennett notes that ethnobotany and ethnobiology are natural links to environmental education (Bennett 2005). The science of ethnobiology, therefore, could

S. A. Vougioukalou (✉)
School of Anthropology and Conservation, University of Kent, Marlowe Building, Canterbury, Kent CT2 7NS, UK
e-mail: s.a.vougioukalou@kent.ac.uk

K. Barfield · P. Harrison
Botanical Research Institute of Texas, Fort Worth, TX, USA

R. D. Huish
Department of Biology, Hollins University, Roanoke, VA, USA

L. Shiels
Department of Biology, University of Hawaii, Hilo, HI, USA

S. L. Brosi
Department of Biology, Frostburg State University, Frostburg, MD, USA

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serve as a suitable candidate to revive an academic interest in the plant world by highlighting the interconnectedness of social and biological systems and the relevance of plant uses in contemporary society.

Ethnobiology may also have an important role in improving plant science and biology education. In the last two decades, undergraduate pedagogy has been changing. Teacher-centered unidirectional flow of knowledge in the classroom is gradually being replaced by student-centered, problem-based learning, not only as a method but as a philosophy of pedagogy (Mazur-Stommen 2006). Biological education as a whole, of which plant sciences are a part, strives to incorporate these changes and better meet the need of the twenty-first century. As the underlying framework for improving undergraduate biology education, the American Association for the Advancement of Science (AAAS) has outlined core competencies that, if cultivated, would enable students to go beyond a comprehension of biological concepts to the successful generation, application, and communication of biological knowledge in a greater societal context. These core competencies, found in their publication *Vision and Change in Undergraduate Biology Education: A Call to Action* (Brewer et al. 2011, pp. 13–14), are summarized in six points:

1. Ability to apply the process of science: Biology is evidence based and grounded in the formal practices of observation, experimentation, and hypothesis testing.
2. Ability to use quantitative reasoning: Biology relies on applications of quantitative analysis and mathematical reasoning.
3. Ability to use modeling and simulation: Biology focuses on the study of complex systems.
4. Ability to tap into the interdisciplinary nature of science: Biology is an interdisciplinary science.
5. Ability to communicate and collaborate with other disciplines: Biology is a collaborative scientific discipline.
6. Ability to understand the relationship between science and society: Biology is conducted in a societal context.

These benchmarks for biology education contain many of the principles inherent in the interdisciplinary and collaborative field of ethnobiology, However, the interdisciplinary nature of ethnobiology also presents unique and exciting challenges to both instructor and student. A previous survey on trends in ethnobotany education in the USA performed in 1996 highlighted concerns regarding limited research funding, respect for the field, for the field, availability of good mentors, strong university programs, and post-graduation occupational opportunities (McClatchey et al. 1999). More than a decade after this survey, we followed up with some of these issues in another survey. The aim of this survey was to evaluate the contributions of ethnobiology to biology education and the trends in ethnobiology education from a faculty and student perspective. In this chapter, we report on four of the survey questions which focus on the ways that ethnobiology may enhance plant science education. We examine student and faculty perspectives on how ethnobiology contributes to core competencies in biology, main methods of instruction and assessment, use of online tools, and strengths and weaknesses of ethnobiology courses.

We also present two case studies of higher education institutions and one botanical research institute in the USA to highlight the diverse contributions of ethnobotany to non-science majors, ethnic minority STEM (science, technology, engineering, and math) student groups, and children and young adults who access informal education.

3.2 Methods

The survey was conducted electronically through an online survey system, SurveyMonkey Inc. (http://www.surveymonkey.com/, Palo Alto, California), that allowed us to capture and analyze the results. We revisited some of the questions asked in the 1996 survey and adapted the content to monitor changes in the growing international field of ethnobiology education. Of the 696 surveys sent to faculty and students electronically, 185 responses were received, giving us a 26.6% response rate. Approval to complete this study was granted by the Institutional Review Board of Frostburg State University on October 21, 2011 (IRB#: H2012–007).

3.3 Results

3.3.1 Respondent Profile

A total of 135 students responded to the questionnaire from 52 institutions. Fifty faculty members responded to the questionnaire from 43 institutions. Respondents represented a total of 84 institutions, 32 of which were outside the United States. and included faculty members and students of both the natural and social sciences.

3.3.2 Core Competencies in Biology

Faculty and student survey respondents were asked to relate their perceptions on how well they felt their ethnobiology program (if they were in such a program) or course (if they were only enrolled in a course) helped them develop each of the six core competencies of a biology education—incapable, minimally capable, moderately capable, highly capable, or greatly capable.

According to both faculty and student perceptions, the core competency that ethnobiology helped to develop the most is “understanding the relationship between science and society” (80% of students and 74% of faculty responded as highly or greatly capable), followed closely by “the ability to communicate and collaborate with other disciplines” (75% of students and 71% of faculty responded as highly or greatly capable). For both the students and faculty, “tapping into the interdisci-

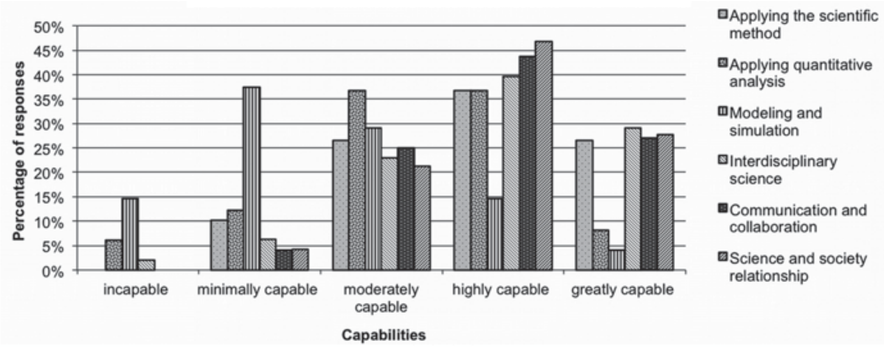

Fig. 3.1 Faculty responses to the contribution of ethnobiology courses to achieving core competencies in biology

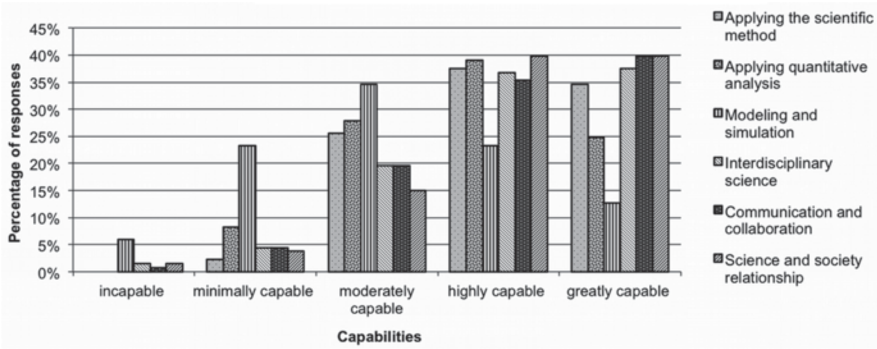

Fig. 3.2 Student responses to the contribution of ethnobiology courses to achieving core competencies in biology

plinary nature of science" followed next, and then the "ability to apply the process of science." The two competencies that students and faculty felt that ethnobiology aided the least in developing were the "ability to use quantitative reasoning" and the "ability to use modeling and simulation" (Figs. 3.1, and 3.2).

3.3.3 Teaching Methods and Assessment

Respondents were asked about how often certain types of instructional methods were used and about what assessments were predominantly conducted in their ethnobiology classes. The categories for instructional methods included: traditional lectures, interactive class discussions/debates, secondary research on published research papers, primary research, inquiry-driven learning based on student questions,

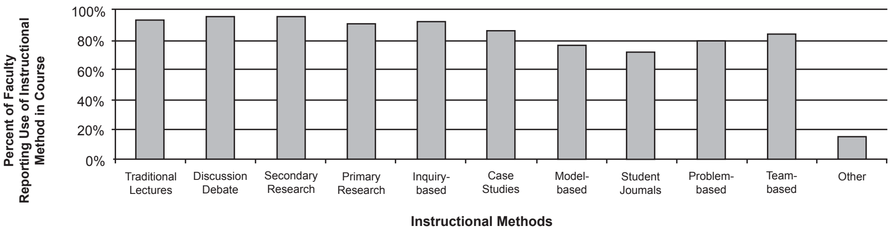

Fig. 3.3 Use of various instructional methods in ethnobiology courses as reported by faculty

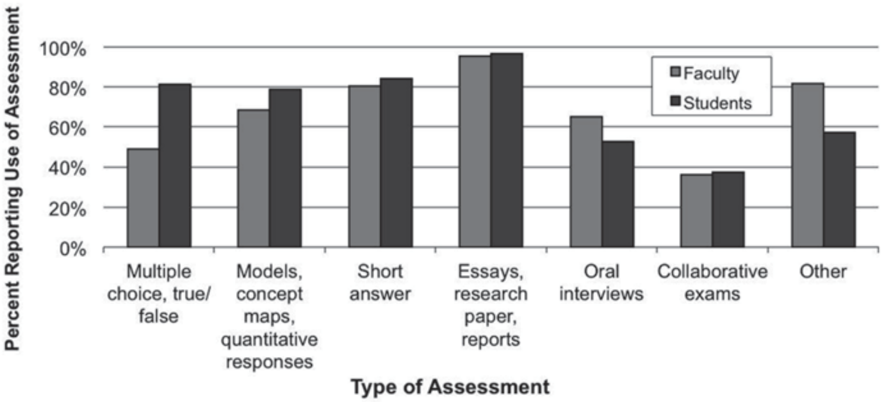

Fig. 3.4 Use of assessments in ethnobiology courses as reported by faculty and students

case studies/scenarios in the classroom, model-based learning of complex concepts, student portfolios, reflections, journals, blogs/websites, problem-based learning where student groups work towards a solution, team-based learning through structured tasks, and other methods. The percentage of faculty reporting the use of each of these instructional methods in their courses is reported in Fig. 3.3. The instructional methods of traditional lectures, class discussions/debates, primary research, secondary research, and inquiry-based learning were all reported to be used by more than 90 % of faculty surveyed. Student journaling and model-based learning were reported to be used by less than 80 % of faculty.

The percentage of faculty and students reporting the use of varied assessments in their ethnobiology courses are reported in Fig. 3.4. Essays, research papers, and reports were noted by over 90 % of faculty and students as being used as a means of assessment in their ethnobiology courses, and short answers were reported by more than 80 % of both faculty and students.

Other teaching and assessment tools written into the "other" category of the survey by students and faculty included plant and animal voucher specimens/profiles, field trips, travel excursions abroad, demonstrations, creating "artifacts," research-

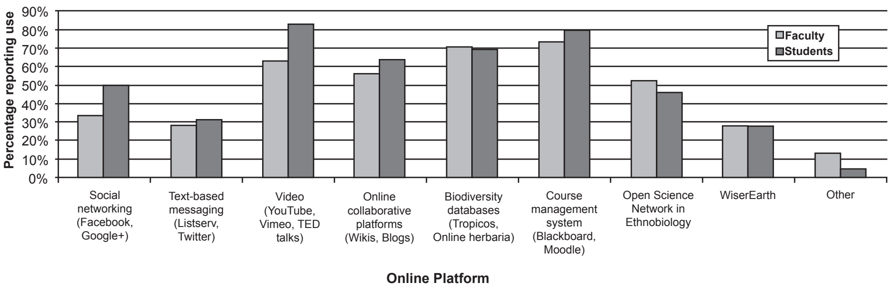

Fig. 3.5 Use of online platforms in ethnobiology courses as reported by faculty and students

ing through old newspapers, formulating a conservation action plan for an endangered species, assigning hypothesis-driven research projects, and collaborating with local native communities. Some of the "other" responses listed by students concerning teaching methods and assessment expressed the desire for more "hands-on" and "research-based" ethnobiology educational opportunities.

3.3.4 Use of Online Tools

Students and faculty were asked to respond on the frequency of usage of the following online resources: social networking sites, text-based messaging, video, online collaborative platforms, biodiversity databases, course management systems, and the Open Science Network in Ethnobiology (OSN; refer to Table 3.1 for further descriptions of these). Results are summarized in Fig. 3.5. Of the listed online resources, the highest reported uses by students were for videos, course management systems, biodiversity databases, or online collaborative platforms. Faculty respondents also had the highest reported uses for course management systems, biodiversity databases, videos, and online collaborative platforms. From this information, it appears that students and faculty members are using similar online resources related to ethnobiology education. As a whole, the respondents reported that they did not use social networking sites (less than 50 % of students; less than 35 % of faculty) or text-based messaging (less than 31 % for both groups) as a regular online resource for learning. Also, 16 faculty and 13 students reported using other online resources, as listed in Table 3.1.

3.3.5 Strengths and Weaknesses

Survey respondents were asked, "What do you feel are some of the strengths and weaknesses of the educational program you attend in regards to ethnobiology education?" as an open-ended question. In terms of strengths, faculty members men-

Table 3.1 Table of specific online resources used by faculty and students

Resource category	Description
Social networking sites	Facebook, Google +, WiserEarth
Text-based messaging	Listservs, Twitter
Video	YouTube, TED, Vimeo, University of Hawai'i Manoa videos
Online collaborative platforms	Wiki's, blogs, Encyclopedia of Life, Google sites, Wikipedia, Web of Knowledge, Web of Science, INPI, Bone Commons, Agrobiodiversity weblog
Biodiversity databases	Tropicos, online herbaria, JSTOR, EBSCOhost Academic Search Premier, Google Scholar, Biodiversity Heritage Library, USDA PLANTS Database, Dr. Duke's phytochemical and pharmacy database, Field Museum database, Dan Moerman's Native American Ethnobotany database, Bishop Museum archives, Science direct, Atrium, IPNI, PubMed, Natural Products Alert database, Germplasm Resources Information Network database, ethnobotany databases, clinical databases
Course management systems	Blackboard, Moodle
Other	Prezi, Elluminate Live, seminars, society websites (Society for Economic Botany and Society of Ethnobiology), variety of individual and institutional websites, Alaska Ethnobotany project, Global Diversity Foundation, online journals, museum catalogs, botanical gardens, Open Science Network in Ethnobiology

tioned that there were high levels of student interest and didactic value. Faculty members were very passionate about the ethnobiology courses they were involved in. One faculty member mentioned that there was "passion for teaching, advocacy, research, and scholarship." They also commented on the potential for ethnobiological research to tackle real-world issues using an interdisciplinary framework that incorporates traditional knowledge. A respondent reported a strength of the program was the links with non-academic institutions such as libraries, museums, and community centers.

Students reported the following themes as the main strengths of their ethnobiological education: good instructors, groundbreaking, eye opening, analytical skills, plant ID, links to botanic gardens, hands-on workshops, links to human health, and opportunity for fieldwork. Methodologically, they valued interdisciplinarity and use of quantitative and qualitative methods, links to conservation as well as development.

In terms of weaknesses, faculty members frequently expressed the need for more classes and funding. One educator summarized several viewpoints by mentioning that there was "vanishing support for travel and fieldwork, lack of support in the majority of biology department faculty, and disappearance of botany." There was also reported indifference and/or lack of support from senior management as well as insufficient numbers of faculty.

Interestingly, when students were asked to report weaknesses, they also frequently mentioned the lack of classes and funding, but also recognized a different set of weaknesses. Students expressed the need for more career development resources and better advertising across departments. Further, students sought for course credit to be offered by more departments than just anthropology and biology, and also for faculty from departments outside biology and anthropology to be involved in the courses.

3.4 Case Studies

We also looked at three institutions affiliated with the coauthors where ethnobiology was used to improve biological literacy. These case studies highlight three diverse scenarios in order to exemplify the breadth of the contribution that ethnobiology can offer within plant sciences and across the disciplines in higher and community-based education.

3.4.1 Hollins University: Incorporating the Plant Sciences Across the Curriculum Through Ethnobotanical Learning Modules

Hollins University (Roanoke, Virginia) is a small, private, women's university dedicated to the interdisciplinary and experiential learning at the core of a liberal arts education. The 11:1 student–teacher ratio lends itself well to student-centered, mentor-relationship learning. While majors in ethnobiology are not offered, ethnobiology concepts are components of plant science and biology education at Hollins University, specifically in biology courses such as Conservation Biology, Plant Biology, and Plants of Virginia to bring relevance and application of biology competencies. Also, three entry-level ethnobotany courses, Appalachia: People, Place, and Plants; Plants and People: An Introduction to Ethnobotany; and Plants in Poetry and Art, capture the interest and improve the comprehension of plant biology concepts by non-majors.

Further ethnobiology modules are offered in many non-biology courses at Hollins University throughout the sciences, social sciences, and humanities, such as Biochemistry; Organic Chemistry; Cooking and Chemistry; Buddhist Traditions; Creative Nonfiction; Creative Writing; Instruments at Hand: An Exploration of

Music Across Cultures; Food, Culture, and Social Justice; Learning from Gaia: Nature, Myth, Archaeology, and the Environment in the Ancient Mediterranean; Principles of Microeconomics; and various studio art classes. The ethnobotany modules have been utilized in many of these courses not just as an incidental component of coursework, but as an effective method to reach the educational aims of these varied fields of study.

For example, to meet one of the objectives of the Food, Culture, and Social Justice course (Anthropology/Gender and Women's Studies/Environmental Studies 219), which is to develop a conceptual framework for understanding food as an interdisciplinary topic of scholarly inquiry, each student participates in a community partnership project with a local food organization such as a local food advocacy organization or community garden. Practical experience cultivating and harvesting plants and the associated civic engagement with these organizations becomes a vehicle for identifying societal and biological connections. In the Principles of Microeconomics course (Economics 157), an ethnobotanical problem-based learning module involved students in conducting semester-long economic analyses (including cost-benefit, net present value, and payback analyses) for the community garden on campus. Efforts students devoted to the planting, caring, and harvesting of the produce helped them become familiar with biological concepts, which aided better economic decision-making, Organic Chemistry (Chemistry 222) students isolate medicinal phytochemicals from turmeric rhizomes and work towards biochemical synthesis of the compounds. Students in the Creative Nonfiction class (English 210/Environmental Studies 250) choose a tree on campus and devote sustained attention to it over the semester. They develop skills of botanical observation and research as they study its taxonomic, morphological, ecological, and ethnobotanical characteristics. From this they build description, anecdote, poetry, and other nonfiction modes of creative expression.

3.4.2 University of Hawai'i at Hilo: Ethnic Minorities and STEM Education

The University of Hawaii, Hilo (UHH) is largely a teaching-based, minority-serving institution (particularly students with Asian and Pacific Islands heritage). Students at this school particularly benefit from a student-based approach and from hands-on activities that engage them. The Department of Hawaiian Studies offers popular classes on Hawaiian ethnobotany and Hawaiian ethnozoology which are strongly based in the local Hawaiian culture. The incorporation of more general ethnobiology concepts and approaches into traditional STEM classes also makes education more engaging for students from nontraditional as well as more mainstream backgrounds. These different, complementary approaches to utilizing ethnobiology education benefit students and the community at this institution. For some students, ethnobiology offers them a way to connect with their native Hawaiian/Pacific islander heritage and perhaps to learn skills of a cultural practitioner. For other students, connecting with topics or projects they find of personal interest and relevance in a science class can help them enjoy the learning process more and be more motivated to study and actively apply the course concepts.

For example, the Conservation Biology class offers a multitude of opportunities for students to actively engage with each other and the local community conducting team projects, community service projects, and suggesting solutions to real-world dilemmas with both biological and cultural components. For instance, there is a major conflict between some local animal hunters and the conservation community in Hawaii. While many activities attributed to hunting are thought to threaten the survival of quite rare, endangered, endemic species in this biodiversity hotspot, many local people view any attempts to limit hunting activities as a plot of the government and scientists to diminish their culture and livelihoods. Learning and applying general skills and tools of ethnobiology and the student-centered approach allow students to collaboratively build creative solutions to such multifaceted problems with equally important ecological and cultural sides. This approach also helps the students build useful skills to tackle these types of issues if they decide to pursue a career in conservation biology.

3.4.3 Texas Botanical Research Institute: Educational Outreach for Young People and Families

The Botanical Research Institute of Texas (BRIT) is a nonprofit scientific research and learning center focused on conservation and knowledge sharing. As a recognized leader in informal botanical and environmental education, BRIT provides a diverse array of programs from early childhood to adults that deepen understanding of plants and the pivotal role they play in the health of our planet.

The focus of BRIT's educational outreach is the local ecology and cultural heritage, a place-based approach to learning. Beginning from an early age, young children explore nature and learn about the plants that are useful in their lives, such as cotton and pecan trees. BRIT's Field School for middle school students explores the plants in BRIT's bio-swales and retention pond to understand how plants filter stormwater before it flows into the nearby Trinity River. Adult learners may choose from a variety of classes that are plant based such as an art class using natural dyes from native plants.

Research indicates that informal education experiences can bridge the gap to formal learning, especially with the underrepresented population BRIT primarily serves, i.e., females and Hispanic children (Bell et al. 2009). For example, elementary children who come to BRIT explore a prairie and learn about the geological history that formed it. As part of their study of Texas history, students play a game that simulates the choices our native people and early settlers made about plants used for food and medicinal purposes that could be found growing on the Fort Worth prairie. As students choose plants to solve their daily dilemmas, they quickly learn the value or harm certain plants have on people. Many children who recently immigrated to Texas excel in these play situations, having experienced uses of the plants in their home country. Through work in teams using a scenario-based strategy relevant to the students' daily lives, this type of informal learning stimulates an interest in knowing more about one's natural heritage.

3.5 Discussion and Conclusion

The survey results and case studies showed diverse ways that ethnobiology can enrich plant science curricula and potentially contribute to the revitalization of student interest and comprehension in plant sciences. The survey showed that ethnobiology was perceived to contribute to core competencies in biology as defined in the *Vision and Change* document (Brewer et al. 2011) and especially to the competencies of "understanding the relationship between science and society," "the ability to communicate and collaborate with other disciplines," "tapping into the interdisciplinary nature of science," and the "ability to apply the process of science." The ability to use modeling and simulation to study complex biological systems, perhaps, is taught in biological courses outside of ethnobiology, but also has the capacity to be further developed within ethnobiology curricula.

The highest perceived frequency of use of instructional methods by both students and faculty were for traditional lectures and class discussions; however, all the various listed instruction methods were reported as used in courses by more than 70 % of respondent faculty. Regarding assessment, both groups of students and faculty mentioned essays, research papers, and reports as the assessment type being utilized most frequently. This highlights that ethnobiology assessment methods still follow predominantly traditional learning models, but it is important to note that instructional methods were also reported to incorporate a broad range of methods including those that are more student centered.

When asked about course strengths, faculty mentioned that ethnobiology courses were very popular among students, and students mentioned they highly valued staff enthusiasm and commitment. Regarding weaknesses, students called for more course offerings, including credit through varied departments, and faculty mentioned lack of support from peers and senior management. Faculty and students particularly called for better funding and career development resources.

Presently, courses in ethnobiology are offered in a much wider variety of institutions than they were a decade ago. This is exemplified in the two case studies of higher education institutions and one botanical research institute in the USA, which highlighted the diverse contributions of ethnobiology to non-science majors, ethnic minority STEM student groups, and children and young adults who access informal education. Interestingly, some issues reported in the 1996 survey still persist such as lack of recognition by the academics and senior management teams. Ethnobiologists need to actively maintain and improve the integrity of the discipline to create a more credible, employable, and outward-facing ethnobiology. This can be achieved through pedagogical development, rigorous interdisciplinarity, and strong links with community partners, and other departments and universities.

As ethnobiology is an emerging discipline with a limited number of textbooks, educators often rely on online resources to cover the geographical and historical breadth of ethnobiological case studies. There is a wealth of ethnobiological curricula, online databases, and audiovisual materials that are available online in different faculty and research center websites. Both faculty and students reported that they are likely to use biodiversity databases or course management systems, video or online collaborative platforms in relation to ethnobiology education.

An example of an online pedagogical resource in ethnobiology is the Open Science Network (OSN) in Ethnobiology, an NSF-funded Research Coordination Network in Undergraduate Biology Education. The OSN has a collection of peer-reviewed ethnobiological educational materials made available online with an aim of creating a resource for people teaching ethnobiology at universities, community colleges, and other educational facilities. This network has begun to work with an other NSF-funded project, the Ecological Society of America's EcoEd Digital Library (http://ecoed.esa.org/). Through this portal, OSN will be able to share resource materials that have been peer reviewed and are ready to be used in classrooms. The OSN has established a community of educators who are striving to bring scientific rigor and curriculum standards to the emerging discipline of ethnobiology education (McClatchey et al. 2013). These online pedagogical tools have the potential to enhance the quality of teaching, create new links between educators and improve teaching outputs through the sharing of teaching resources.

In conclusion, faculty and students in the field of ethnobiology show confidence in the contribution of ethnobiology to core competencies of biology education. Faculty are employing varied teaching methods and mediums, and as ethnobiology grows and gains recognition, it can make an ongoing contribution to plant science curricula and potentially contribute to the revitalization of student interest and comprehension in plant sciences.

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Chapter 4
From Learning to Teaching: Bridging Students' Experience and Teachers' Expectations

Valentina Savo and Ursula M. Arndt

4.1 Introduction

Teaching entails a life-long learning process. Some people are naturally gifted orators and teachers, while others need to learn how to deliver a lesson in an effective way. Whatever the background, skills, and personalities, teachers ideally never stop learning from their experiences and improving their teaching styles over time. This is becoming easier for instructors thanks to available publications on teaching methodologies, blogs, websites, and the increased number of technological resources available in class.

Today, the view of learning as a passive process is becoming less common among teachers and in university programs. New more active and interactive teaching methods are flourishing, increasing the learning opportunities for students. For example, methods such as project-based learning (Thomas 2000; Helle et al. 2006) and problem-based learning (Hung et al. 2008) are based on different theories such as constructivism (Fosnot 1996; Staver 1998) and student-centered approach (Burrowes 2003). While opportunities for students are increasing, teachers are challenged with extra workloads. Moreover, teachers may use a wide array of different teaching strategies and methods, which can only be implemented successfully if they know how to use these strategies effectively.

Teaching science comes with a specific set of challenges. Scientific methodology is not a part of a novice student's daily life, and introductory biology classes usually include the memorization of a vast technical vocabulary (Leonard et al. 2001).

V. Savo (✉)
Hakai Network for Coastal People, Ecosystems and Management,
Simon Fraser University, 8888 University Drive,
Burnaby, BC V5A 1S6, Canada
e-mail: vsavo@sfu.ca

U. M. Arndt
Department of Anthropology, Kwantlen Polytechnic University, Burnaby, BC, Canada

Department of Archaeology, Simon Fraser University, Burnaby, BC, Canada

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Some concepts are complex and require backgrounds in other disciplines (e.g., explaining photosynthesis requires basic understanding of chemistry and physics). Moreover, students in urban environments do not always have the opportunity to observe natural phenomena and processes in their surroundings and thus might have difficulties in imagining concepts explained in the classroom (e.g., it may be difficult to explain to students what humus is and to describe the smell of the humus on the ground of a forest if they have never walked in a woodland).

Instructors develop their ideas about teaching based on personal experiences as students as well as on preconceived notions (Kroll 2004). The amount of previous practice as teachers is also important, as well as other factors such as international experience with different cultural backgrounds and settings and exposure to different languages and customs. Former training in other and diverse disciplines can also affect teaching style, especially if those disciplines are related to education, sociology, or psychology.

In this chapter, we will talk about our personal teaching and learning processes and challenges. Based on our experience, we will discuss why we consider it important to remember your life on the other side of the desk and never forget the problems faced in learning, dealing with class assignments, pre-exam stress, etc. We believe that our main goal as instructors is to deliver knowledge and skills, which hopefully will remain with students long after the conclusion of a course.

We will also discuss how we are trying to use our experiences to make complex subjects interesting to our own students today, since we have both recently started to teach botany, ethnobotany, and bioarcheology. The focus will be on the incorporation of (ethno)botanical concepts in lessons, and related practical experiences in classroom settings. Different plant uses can tie everyday life of students to physiology or anatomy of plants, as well as illuminate past cultures and connect these to modern cultures. We hope that this transdisciplinary approach will help potential educators in their journey to prepare and execute successful lesson plans. We also hope that this chapter will help educators in reaching their students more effectively through recognition of the different backgrounds and perspectives of students.

4.2 From Learning to Teaching

Our own experience as students has modeled our attitude as teachers. We have been sitting in classrooms trying to learn concepts related to plants and humans that were tedious at times and simply fascinating at other times. Here we will describe some of our most memorable learning experiences and discuss how they have affected our teaching approach.

4.2.1 Our Experiences as Students

4.2.1.1 Positive Experiences: Baby Steps

Many young students do not like math, and this dislike can last until maturity. To some degree, it seems fashionable to be "bad at math." My earliest experience with a teacher who explicitly put effort into teaching a difficult subject was my fifth-grade math teacher. He was a students, middle-aged man who obviously enjoyed what he was teaching. Like many other students my age at that time, I was bad at math, barely passing my elementary math class. While I had good grades in other classes, math was not my forte.

This teacher started his class explaining to us that, while math can be tricky, it is not as hard as people imagine. He told us that we would learn in small steps that would let us understand the big picture, as well as specific mathematical concepts. He did just that, planning the class in a way that would teach one step at a time and it worked. The class average rose from a low C to a solid B (within a grade system where A is the maximum and F is a fail). For once, math was not the hardest, most hated class. The teacher was and remained a class favorite.

Even today, he is one of the teachers that I would consider pivotal not just to my academic career, but to my understanding of teaching and learning. Later in university, the best teachers were engulfed in their subject but still had the ability to "walk" us through the details. This ability requires detailed knowledge and passion for a subject, but for me as a student it is well worth it and less scary than being thrown in at the deep end. I guess that the same happened back in fifth grade.

A second strategy that has helped me learn is "hands-on teaching." Giving students the opportunity to touch and do their own "research" is an incredibly powerful way of teaching. Even "boring" or "complex" subjects become interesting when they can be applied. Standing ankle deep in a local river to count fauna, observe the flora, and measure the water quality has more of an impact than any picture seen on an overhead. I would argue that this is at least as much, or even more, true in the current times, when students take notes on computers and have the Internet available all the time. "Hands-on teaching" also gives students the opportunity to engage with their peers and teachers, a very different dynamic than the rather one-directional instruction in a normal classroom. This approach is supported by a large body of research (e.g., Hartman et al. 2000; Eick and Reed 2002). Traditional lectures have their merit and are probably not completely replaceable any time soon, but the attitude that the instructors bring to the class, their approach to a class and offering alternative methods (e.g., active research, project groups to prepare presentations) are a good way to open the material to those students who may get lost in a traditional teaching atmosphere.

4.2.1.2 Positive Experiences: Indiana Jones

I have always had a strong curiosity about topics related to ecology and biology. Since I was a child, I have been surrounded by nature, and loved to explore tree canopies and observe the small animals and creatures under stones or in ponds. When I had to decide upon my university track, I chose biology without any hesitation. Sitting in a class, however, was not as interesting as expected and not as fun as walking in a woodland. This was especially true for my undergraduate courses.

The majority of classes during my undergraduate experience were lecture based, with the exception of a few laboratory classes. While one of my favorite professors did not have a different teaching strategy (his classes were frontal), he did have a different teaching "attitude." Above all, he was passionate in what he was teaching. Other teachers were interesting, but it was akin to watching documentaries, while sitting in his class and listening to him was like watching an Indiana Jones movie. He was fun and interesting, enriching his classes by using examples from his past experiences and adventures in the field. I enjoyed his classes, even if the topic he was teaching was not my favorite.

The second positive experience has been very powerful for many reasons. I have never learned so much in such a short time. First of all, it was the first time that lessons were not lecture based, and students were engaged in discussions, while the instructor just kept the discussion within the proper boundaries. My first reaction, I should admit, was skeptical; this approach was just so strange to me. Then, I started to really enjoy this new learning/teaching method. I also started to think and reflect about what I was learning, no longer only absorbing information. In that moment, I realized that there were different ways to learn and that learning could be fun, challenging, and incredibly interesting.

This class was unconventional to me also for other reasons. During the course, there were many practical experiences that involved not only visual and manual practices, but also tasting experiences. The involvement of different senses in the learning process, at least in my case, was extremely powerful and incisive. In my personal experience, I rarely had difficulties understanding concepts, but memorizing them has always been tricky for me. It took me some time to understand why. I can easily memorize pictures and numbers, and I have a selective attention. I had to really put a lot of effort into learning in lecture-based classes, but I still have vivid memories of almost every single class in that course.

Finally, the concepts taught in this course were always bridged to other topics. I have always been amazed by and interested in how things can be interconnected. Moreover, I found it easier to memorize concepts if they were tied to facts that I already know, and especially if I could find connections about these notions across disciplines (see Seifert et al. 1986). I believe that this approach is valuable, especially for the student. The teacher teaches his/her own discipline and, at the same time, he/she is facilitating the memorization of concepts (reducing the homework load) and expanding the worldview and conceptualization skills of students.

4.2.1.3 Negative Experiences: Unengaging Classes

Our negative experiences shared a common feature; classes were boring mainly because instructors were unable or unwilling to engage students. One of the main problems in universities is that often teaching is still seen as a passive process where students can obtain their degree without questioning and by absorbing the delivered knowledge (Thijssen et al. 2002). If information is the only thing that matters, there is no motivation for students to sit in a class if they could get the same information from textbooks.

It has long been documented that students have different preferences for learning styles (James and Gardner 1995; Miller 2001; Pashler et al. 2008). Students have different attitudes, skills, and backgrounds resulting in different performances that vary according to the different strategies in memorizing and learning. Moreover, students have different and personal preferences for the various topics. All of these factors could affect students' preferences and opinions about their teachers. However, there are teaching approaches that are considered consistently negative and some widely appreciated by students. Instructors we found interesting might not have been interesting to other students. Conversely, we may dislike instructors that other people appreciated for certain traits.

We both had a negative experience with an introductory course at university. Introductory classes generally are intended to deliver a huge amount of information that creates the background for the following courses. Looking back, the main problem was that the instructor lectured the material without creating context and without making it relevant to the topic or to us (as students). At that time, the concepts were so decontextualized that we were not able to perceive their importance. These concepts became relevant only after a few years and in more advanced courses. However, the information only became clearly relevant because we continued taking classes despite our initial disappointment. For students who drop out of school or from the specific stream in the first year, these concepts will always remain foreign and will never be useful for their personal and academic growth. The fact that the amount of information in these classes is vast and that students are new to the university system make these courses rather challenging for instructors as well.

4.2.2 In Transition: From Learner to Teacher

When we started to think about our past experiences, we realized that we had several common opinions, observations, and ideas. This is rather curious since we had quite different backgrounds (personal, cultural, and social, not to mention academic). However, we also wondered if we had somehow different attitudes in common as students to begin with, since we both would move on to graduate school and eventually work in academia. We started to think about what makes students decide among the different paths for their future careers.

Several factors may affect the decisions of a student about his/her university and learning track. There is a vast amount of literature analyzing and modeling these factors (e.g., Johnson 2000; McKenzie and Schweitzer 2001; Nora et al. 2005). These factors span from very personal motivations and experiences to culture, religion, economical issues, etc. In our specific case, our motivation was that we both liked learning and enjoyed challenges. At university, we endured despite obstacles and difficulties with the introductory classes.

Generally, students withdraw from higher education during the first year of college (e.g., Pitkethly and Prosser 2001). Sometimes, first-year students are still mentally in high school and may have to get used to becoming more independent. In some cases, students pick a class or topic without having an in-depth plan or idea of their future goal ("It sounded like fun" or "It was the first interesting subject in the course list" or "I saw it on TV"). If instructors are not able to engage students, they will drop out and may not come back to become senior students. On the other hand, senior students generally have already pondered and persisted in their learning process and have invested in their education. These students either have or have developed an autonomous curiosity for the subject and for learning in general. These differences should be considered by instructors when planning an introductory or advanced course. Fortunately, experienced professors can tell new faculty that an instructor can only influence a fraction of students. There will always be students who do well, and a small amount that will be less successful independently from factors such as the enthusiasm and ability of the instructor.

Since we were students, a lot has changed in academia. Instructors and universities have embraced new teaching philosophies and incorporated and applied creative teaching methods in their courses and classes. New technologies and resources are much more easily available to students, and these have been increasing at a very fast pace lately (Smith et al. 2009). Instructors in this era of transition may have several difficulties in trying to incorporate technologies that they themselves were not trained to use (in school) or adhere to new teaching methods that they have never experienced.

Ideally, universities should prepare students to face a rapidly changing environment. Educators can, to a certain degree, prepare students to adapt to new job situations, multicultural settings, and technological changes by sparking their curiosity and encouraging them to become lifelong learners (Brown 2002). We (as educators) need to learn from both the positive and negative models we have experienced in the past, learn new teaching methods and approaches, incorporate new technologies, and integrate students' needs into our courses.

4.3 Applying Experience as Students to Teaching

Based on our experience as students, we have selected three main features and "lessons" that seem to be recurrent in our stories.

4.3.1 Small Steps: How to Balance Student Engagement with the Delivery of Essential Information

Defining the fundamental content of your course before starting is essential. If you want students to learn 20 main concepts, teach them these concepts instead of teaching everything you know hoping that students will, at least, remember these main concepts. After being a university student for more than 10 years, it can be difficult not trying to share everything that you know about a topic. We learned that we had the best grades and best performances during oral exams if we were talking a lot. The first teaching year comes with the perils of feeling judged and the need to impress. The first instinct is to over-share all of your knowledge because you want to give the impression that you are well informed and a good teacher, but sometimes also because you are full of enthusiasm. After becoming an "expert" in a subject everything seems relevant and your excitement may lead to teaching too many facts that a student cannot follow. The dramatic result is usually a convulsive lecture full of information. It may take some time to understand that these sorts of lectures are the ones that we classified as boring when we were students.

Learning the art of synthesis is a main goal at the beginning of the career of an instructor. Just like learning to communicate information in journal articles, communicating a balanced amount of information to an undergraduate audience needs to be learned. Too much information can overwhelm the student and hinder inspiration and enthusiasm. We also have to remember that for some of the students in class, this might be the only opportunity that they will have to learn about botany, ethnobotany, or bioarcheology. Especially for these students, it is more important for them to understand and learn a few concepts rather than have a vague idea about many concepts. The ability to communicate clearly and concisely is not just necessary in the classroom but in general. Very few people are specialists in the same field, so we will be dealing with nonexperts on a daily basis. It is important for students, whatever their future field of expertise, to learn some basics that can help them to be more critical in the future (and notice discrepancies in news articles, documentaries, or museum exhibitions). Perhaps, some of them will even be excited enough to take an additional class.

Students taking botany classes have to learn specific terms that are important for understanding core concepts and taxonomy. However, they need to learn them progressively. Botany teachers should avoid presentations full of information and technical terms. As experts, we tend to use technical terms on a daily basis and might have a different perception of what is a difficult term or concept. In other cases, we may just believe that if students learn the basics of botany at the beginning, they will be able to appreciate the beauty of the following more complex botanical topics.

Again, everything feels important in the beginning. However, students do not need the full wealth of technical terms to understand concepts or explain complex processes. What is more important is to explain to students how they can look for information (if they want to enlarge their perspective on specific concepts) and how they can critically select the most relevant sources. Students also need to learn how to deal with difficulties (e.g., a boring class) and to continue despite initial failure (Schwartz 2008).

4.3.2 Hands-on Learning

Learning the theory is one thing, but being able to apply and test it out is another. You do not learn to drive a car by simply learning the theory; you need to get into the driver's seat and practice. Finding ways to provide students with some practical applied experience can be challenging but rewarding. Practical experiences, according to our experience, are generally well accepted by students. Thus, it is not surprising that we both had positive memories about hands-on experiences.

There is a wide wealth of papers discussing the efficacy of different hands-on teaching strategies (spanning from journal writing to field experiences; e.g., Fink 2003; Sliško and Planinšič 2010; Jara et al. 2011). While hands-on learning can be an important tool to foster the learning process, it is equally important to carefully plan these exercises based on the ability of the student (e.g., Ford 1978; Svinicka and Dixon 1987). For example, more novice students can practice concepts and newly learned plant morphology by collecting plants in their own backyard or kitchen-gardens and identifying and comparing them in class. In subsequent lectures, this activity can be used to compare the modern ecosystem to past ecosystems, discussing changes of species diversity and climate over time. More advanced students can plan and prepare mock research proposals, integrating basic knowledge with newly gained insights into the latest advances in the field. In addition, they can have the opportunity to think through a potential research project and learn about scientific methodology. In order to foster the understanding of relevant information of a film shown in class, a worksheet with a set of questions might enhance the learning experience as well, shifting the teaching segment to a more active participation.

4.3.3 Making Topics Interesting

Information is remembered better when made relevant to the learner. This could be difficult in introductory classes, as specific concepts need to be contextualized both within the discipline as well as within the student's knowledge and interest base. An understanding in plant anatomy is necessary to succeed in more advanced botany and ethnobotany classes. The reasons for students to know about plant anatomy or plant DNA sequencing should not be limited to the fact that these topics "will be on the exam," but rather because knowledge of these topics will create a foundation for a variety of more advanced topics.

"Difficult" is a relative concept and depends on the learners' experience and background, but also on teachers' ability to deliver information effectively. Students can learn difficult concepts if the course is developed in baby steps, where complex topics are gradually approached. Information should also be meaningful for students. A good strategy for stimulating students' interest and willingness to learn could be highlighting how specific information might fit within a wider picture. Information could be contextualized in order to become relevant for students' everyday life or their world (e.g., how plant distribution in the past could give us clues about current climate change, the use of food, and medicinal plants today and in the past) and in the specific discipline (e.g., molds and the discovery of antibiotics). For example, archaeology is currently discovering the "Paleo diet" as a vehicle to educate the public about prehistoric people's health and diet and how our lives have changed over the past 10,000 years. This topic can also be used as a starting point to talk about plant domestication (e.g., Warriner 2013) and plants used in modern diets.

4.4 Turning Teaching Theory into Teaching Practice… and Experience

University instructors are usually not explicitly trained in pedagogy. We are trained to become researchers, rather than teachers, and many consider themselves researchers before teachers. We have both attended classes focused on teaching in academia. These classes can be very helpful for increasing self-confidence in teaching and for learning about current teaching/learning/approaches and how to apply them into practice. There are several websites, courses, and seminars that provide, to different extents, a background in teaching methods or resources (e.g., the OSN (Open Science Network, http://www.opensciencenetwork.net/) or the internationally known Instructional Skills Workshop (ISW), http://iswnetwork.ca/). However, practice and theory are two different things.

Preparing a lecture, especially for the first time, can be challenging. Our curiosity as researchers may lead to extra research on the topic at hand, finding possible connections and additional examples. While textbooks are helpful as teaching tools, examples provided in the textbook might not fit what the individual instructor needs for clarity or simplicity for the particular class. However, learning how to develop and create modules and lectures is much simpler than managing an entire course. Lecturing constitutes only a small part of workload, which also includes answering questions, finding additional educational material, grading, corresponding with or receiving students; activities that consume a surprising amount of time. Moreover, to stay on top of current scientific findings and theory, teachers need to revise their modules, material, and examples on a regular basis in order to maintain authentic passion and enthusiasm for the course.

A lot of "good teaching" will come with experience. Besides all training courses, preparedness, enthusiasm, and good intentions, only practical experience can give teachers the sense of what teaching really means. For example, courses do not teach you how to deal, emotionally, with disinterest or drop out of students. While it is possible to increase attention of students in class by using alternative strategies, it is not always possible to impede withdrawal from schools. Inexperienced teachers may perceive this as a personal failure, which may reduce the enthusiasm in teaching.

While teaching might be demanding and tiring, it can also be extremely rewarding. When you see a student looking at leaves of a bush while she is waiting for the bus after your class, a student unexpectedly delivering a great presentation, or someone is grateful for your advice, your hard work pays off after all. As much as teaching can be frustrating, wading through beginner's mistakes and paperwork, being able to tell a student that he/she did great is well worth it, especially if these students are not popular or outspoken in the class. Moreover, keeping in mind that not all of the students are trying to cheat or lie to get out of an exam is an important part of positive interactions with the class. Many mistakes are honest mistakes, and students are trying hard to adjust to the new environment of higher education. Experience or advice in the form of anecdotes from more senior faculty members may lead to a less stressful environment for the new instructor that is navigating the perils of student interaction.

4.5 Lifelong Learning Teachers

Students today are generally exposed to a large amount of information. When we were students, information was only available in class from teachers or in books, generally in libraries. Researching a topic could have taken several days and many hours of searching for pertinent literature. Today, information is easily available to students, and the search for relevant data could take only minutes to a few hours. Teachers and books are no longer the easiest way to obtain knowledge. The result of this easy "accessibility" is that students have less interest in sitting in a class if they can get the same information faster otherwise (e.g., on the Internet). Instructors need to balance between proven and successful lecture methods and new digital environments to lead the class toward (and through) the material taught.

Teenagers and young adults, and thus college and university students, are accustomed to fast technology and are connected to each other through social networks. Students are constantly exposed to facts, information, concepts, and thoughts. The time one can spend on each piece of information, consequently, has to be minimized; concepts are quickly processed and categorized. While teaching, we have to keep this in mind, keeping students interested in a class for more than 5–10 min can be hard. A variety of strategies can be used for making the content of a class more appealing. One strategy could be switching tasks or mode of teaching every 10–15 min. Other strategies include adding "weird science" (quote from a student) and information that is directly related to the students' life, to the lecture.

Finally, novice students frequently accept information uncritically. Providing space to question and develop critical academic thinking can help students to learn how to argue, defend, and criticize information in discussion and writing equally. Critical thinking might be one of the most important skills one can learn in university. Students will eventually obtain more information about the topic of the course through other sources, but they need dialectic skills (defending and supporting their ideas, questioning the source) when trying to convince other people that we should save forests instead of logging. For this reason, it is also important to observe students, how they behave and interact with each other, and to be open to questions from students, in order to provide them with what they need most to succeed.

4.6 Conclusion

The transition from learning to teaching can be challenging. Some common themes seem to reverberate among students, and thinking about these can help new instructors make better choices and the learning curve less steep. Here, we have identified four suggestions, based on our experience as students and teachers, for newly minted instructors:

1. Enthusiasm is a great attribute to get students engaged.
2. Make concepts accessible by breaking it down into manageable units.
3. Provide practical experiences in the course whenever possible.
4. Contextualize information in a way that is meaningful for students.

Perhaps our suggestions will be considered naive by experienced instructors. With years of teaching, our ideas and ideals will likely change. Yet, this is also an exciting time: our student experience is still relatively fresh while we are already full of ideas and enthusiasm for our new challenges as teachers. Can we create a better learning experience for new students based on this? Can we integrate our experience with our own students' experience and accept that goals and attitudes might be different?

We have learnt a lot about teaching while writing this chapter. The discussions helped us to identify common problems, despite teaching different disciplines. Discussions and exchange of ideas with students, colleagues, and experienced professors are important moments for improving our skills as teachers. This is especially true in a world that is changing at an incredibly rapid pace. Keep learning.

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Part II
Introducing Fundamental Skills

Chapter 5
Research-Based Learning

Gail E. Wagner

5.1 Introduction

Research-based learning may center around a number of broad learning objectives: (1) how to conceive and pose a research question; (2) how to test the question, whether through primary or secondary research (or both); (3) how to structure and present the research process and findings; and (4) how to practice research integrity. Research-based learning incorporates critical thinking (e.g., Nosich 2009) and inquiry, and is an example of active and experiential learning.

In this chapter you will not find instructions on how to incorporate laboratory research into your classroom, but rather ways to help your students improve their out-of-laboratory primary and secondary research skills and understandings. The broad research-based learning objectives listed above are skills that enable students to apply STEM subject matter and concepts from the classroom to better negotiate day-to-day life. Students who learn these skills and become scientists should be able to better communicate science to others; students who learn these skills but do not become scientists should be better to able to evaluate scientific findings.

In the following pages I provide several examples of research-based projects, exercises, or assignments that I have used in class, in order to illustrate how to incorporate research-based learning into your classroom. For over 15 years, I have been using long-term group projects to teach students research methods and scientific inquiry. I have found that having a single project that we all work on together is beneficial because it allows us to share a common literature and database that can grow from year to year. My projects, which span multiple years (averaging 5 years) and sometimes multiple topical classes (e.g., students in classes in Ethnobotany, Ethnoecology, and Anthropological Inquiry all work on the same project), have included studying home vegetable gardens, asking people what (and why) plants are special to them, asking people to define vegetables and fruits, examining botanical

G. E. Wagner (✉)
Department of Anthropology and Associated Faculty, Environment and Sustainability Program, University of South Carolina, Columbia, SC 29208, USA
e-mail: gail.wagner@sc.edu

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knowledge or ecoliteracy, and exploring biocultural diversity (Wagner 2002, 2004, 2005, 2007, 2008, 2010a, 2012). In all of these anthropological projects focused on botanical topics, I required my students to interview other people; collect standardized interviews; share the data collected by the entire class; but then write individual, hypothesis-driven papers on the entire data set (and optionally also on data collected in earlier years). Conducting human subject research requires specific training and close supervision (e.g., CITI 2013). However, in the following pages I will describe how to use research-based projects or assignments that do not include human subject research.

Rest assured, to incorporate the material discussed in this chapter into your classroom, you do not need to begin a long-term, student-assisted research project. Instead, in this chapter you will find short, in-class or take-home assignments that may help teach your students to become better researchers. I begin with thoughts on how to structure a class to learn research skills before moving on to talk about teaching basic secondary research skills, how to conceive and pose a research question, how to test or support the research, and how to structure and present research. I end the chapter with a discussion of teaching academic integrity in research.

5.2 How to Structure a Class to Learn Research Skills

Research takes various forms, including primary research (e.g., collecting original data) and secondary research (e.g., collating data from previous studies to learn about or address a research question). Primary research often begins with secondary research. The best way for students to learn research skills is to actually practice them, with guidance (Kirschner et al. 2006). This chapter is written with the assumption that biology educators are already well acquainted with primary research conducted in the laboratory, but perhaps may find useful some ideas on how to structure a class to learn other sorts of primary and secondary research skills.

5.2.1 Principles to Guide Teaching Research Skills

I propose a few basic principles that may help guide how to structure a class to learn research skills. These principles will come as no surprise to an experienced instructor. First, the instructor needs to clearly define learning objectives (e.g., Do you want students to understand and demonstrate the scientific method? Do you want them to be able to substantively annotate a scientific article?). Second, students will be most engaged when they understand the relevance of the lesson or learning experience to their lives. Studying everyday phenomena—things that are all around us or taken for granted—may not only provide the most "aha!" moments, but also become topics that the students themselves want to talk about with family and friends.

Third, incorporating the use of tools the students themselves have available (e.g., cell phones or Internet resources) helps students to conceive of continuing research on their own. Finally, a willingness to experiment with alternative ways for students to present their research findings may result in more imaginative and personalized ways to communicate science than you had ever before imagined (e.g., Wagner 2010b, 2011b).

Clearly defined learning objectives can be communicated to the students through a number of practices on the part of the instructor. One is to focus the flow of lessons to contribute toward the learning objective(s).

5.2.1.1 Talking Points: Vegetables

For example, American children are often told that eating vegetables is healthy. Yet, as my students learned by asking people to define “vegetable,” this category of food is poorly defined and lacks clear cultural consensus (Wagner 2007). One type of vegetable—the tomato—is particularly thought by some to be a vegetable, and by others to be a fruit even though in 1893 a federal ruling legally declared tomato to be a vegetable (Nix v Hedden 1893). I can tell you that 5 years and more after participating in primary and secondary research on vegetables, students continue to contact me to relate additional stories, research, or experiences with vegetables.

5.2.1.2 Integration of Technology in Assignments

For example, in one low-level undergraduate class of 50 students, earlier assignments provided the research, substance, and practice for the final assignment, which was to make individual 4-min YouTube academic videos on an environmental justice or land issue for any choice of North American Indian tribe or nation. The learning objectives for the final assignment included: (1) demonstrate placing a local problem within a national or international context; (2) demonstrate ability to present a researched topic to the general public via YouTube; and (3) demonstrate how to correctly cite sources using a style guide.

Students were first introduced by readings and lecture to differences between indigenous and Western worldviews (e.g., Margolin 2005; Schelbert 2003), and discussed how worldview would influence a society’s relationship with land and nature. The first assignment was to choose a tribe or nation and write a 4–5-page directed paper summarizing that tribe. I provided a list of topics and requirements for that paper and the sorts of sources allowed (and how to cite them). The second assignment was to write a 3–4-page paper on an environmental justice issue or land issue that affected that tribe but that also placed the issue in national or even international context. Again, sources had to be properly cited. At any stage along this process, a student could discover that his original choice of tribe or issue were not compatible, and he could opt to change one or the other. The third assignment was a paragraph summarizing the proposed video paper. The fourth assignment was to condense the earlier two papers into the proposed script for the video, plus list the references cited (now including also sources for images) following a style guide I had provided. The final assignment was both to produce and post online on our class YouTube channel the video paper (including a list of sources for subject matter, images, and sound), and justify grades for the student's own video and two other assigned class videos using my grading rubric. Along the way, I spent class time as well as individual homework comment time about how to research a topic; how to cite sources using my chosen style guide; how to use the chosen, user-friendly, free software to make a "movie" (actually a slide show that looks like a movie) on a PC; how to post the movie on our class channel; and how I would grade assignments using the posted rubrics (Wagner 2011a, 2011b).

5.2.2 Flow of Lessons Should Lead Toward Learning Objectives

Rather than assuming that students already are expert in research steps (Kirschner et al. 2006), a second classroom practice that can reinforce learning objectives is to devote a bit less time on factual content and instead spend some time on procedure and "how-to," as briefly indicated in the examples. Finally, posting grading rubrics that specify how a student may demonstrate mastery of a learning objective or assignment can reinforce your learning objectives.

5.2.2.1 Teach, Practice, and Model Research Skills

Research skills and practices need to be taught to and practiced by the students—for example, reading assignments that require the students to substantively annotate selected academic articles do not translate into recognition by the students about the citation customs within the articles they just read. Instead, if you want students to learn how to correctly cite sources, you need to specifically teach them how to do so. Likewise, if you want students to write short but substantive annotations, you need to work with them in class about how to so.

Research skills also need to be modeled by the instructor. As is said, actions speak louder than words. If you do not cite the sources of your ideas at the end of your PowerPoint slide show, and if you do not properly cite the sources of the illustrations in your slide show, your message to students is mixed. If your written assignments do not follow the good tenets of writing that you require from students (e.g., clear topic sentences, each paragraph restricted to one main topic, logical flow), then students may wonder why they should be required to work on something that clearly is not needed to fulfill the job description you model by your actions. If you post material on your web page that does not meet fair copyright use, or give proper attributions, again you are modeling bad research skills.

5.2.3 Teaching Basic Secondary Research Skills

Skills involved in primary research differ widely by subject, but may include skills ranging from how to use equipment, how to collect adequate data, to how to conduct interviews. What I am calling secondary research encompasses a number of skills, including how to find acceptable sources of ideas or data (i.e., how to conduct a literature search and assess quality), and how to utilize time wisely to research ideas. In this section I will concentrate on secondary research skills, beginning with those related to online research.

5.2.3.1 Digital Literacy

These days, it is irresponsible not to teach digital literacy (Anderson and Rainie 2012; Purcell et al. 2012b). Internet use is high among Americans of all ages (82 % of adults age 18 and older: Zickuhr and Madden 2012), and most Internet users conduct research on the Internet. By digital literacy, I mean (1) how to conduct an online literature search; (2) how to judge the quality of the information found online; as well as (3) fair and ethical use of online research.

Because most students will use an online search engine to find research material (Purcell et al. 2012a, b), an instructor needs to discuss how to use online search engines such as Google Scholar, as well as when or if it is appropriate to use Wikipedia. One survey of teens who conducted research showed that 94 % relied on an online search engine such as Google, but only 17 % used online databases such as JSTOR and 12 % turned to printed sources (Purcell et al. 2012b). Altogether 53 % of American adults consult Wikipedia (Zickuhr and Rainie 2011) as do 75 % of teens in one survey (Purcell et al. 2012b). National studies indicate that "younger generations that grow up relying more exclusively on the Internet are not likely to shift to traditional media as they age" (National Science Board 2010, p. 710). The Internet has become a major source of information about science (Horrigan 2006).

On the day when covering how to conduct secondary research, ideally, you would arrange for your class to meet in a room where each student has an online computer and the instructor's computer screen can be projected. It may be possible for you to arrange for this topic to be taught by your institution's reference librarian, or you may give the session yourself. This class is most useful when each student is required to demonstrate, before the close of class, that he found additional, high-quality literature germane to a topic.

Little research has been done on how Americans assess the reliability of online science information (National Science Board 2010, p. 7.11), but most who use the Internet for science feel "the Internet is a reliable source" (Horrigan 2006, p. ii). Yet teachers' assessments of teens who conducted online research report that 71 % displayed only fair to poor ability to recognize bias in online content, and 61 % displayed only fair to poor ability to assess the quality and accuracy of information they gained online. Only 1–3 % displayed excellent abilities to do either (Purcell et al. 2012b). It is difficult to convince students to use the science citation index (i.e., an online database), but I often require that at least one source for an assignment be an actual book from the shelves of the library, or a peer-reviewed journal article. You may want to point to the science citation index as a way for students to evaluate the quality of sources found online by other means.

Through the years, my students have demonstrated confusion about a number of research standards that academicians often take for granted and therefore do not always think need to be taught. Students do need to be taught the difference between primary and secondary sources (and how to find the former); what constitutes a peer-reviewed source and why its quality is higher than something that was not peer reviewed; and the differences or not between an article or chapter in an online journal or book versus articles or books from the library versus an article posted on a web page or blog. On the one hand, these last examples involve whether something is peer reviewed, but what a student finds especially confusing is how to properly cite these various sources. I will talk more about citation of sources under Sect. 5.3 on "Teaching Academic Integrity in Research."

5.2.3.2 Reading for Ideas

It is possible to teach your students how to write substantive annotations or notes on research readings. Once students have practiced how to summarize an author's ideas, you can progress to teach them how to research for ideas.

My method for teaching how to substantively annotate articles is to provide an explanatory and illustrative handout, discuss the assignment in class, and then assign multiple annotations over time. It is vital that the first annotation is substantively graded and turned back to the student before assigning a second annotation. One mentoring strategy is to give the students *your* annotation of the same article when you hand back the first graded annotation, so that they can compare theirs to yours. You may wish to repeat this strategy several times, especially after an especially complicated reading assignment. If you teach them how to annotate and grade them critically, you will see undeniable improvement in annotations over time.

Substantive Annotations A good annotation begins with a short summary of the purpose of the article. It then summarizes the main ideas conveyed in the article and, when appropriate, summarizes the data. It does not narrate the order of the article, nor does it retell any illustrative stories or examples. It may list the sorts of examples used to illustrate any particular point. It does not include the opinions of the student, although the student may make a critical assessment. The student should never rely on quotations to annotate an article: instead, the student needs to practice using her own words and phrasing to summarize someone else's ideas. If a (rare) quotation is used, the page number must be cited.

5.2.3.3 Research for Ideas

Once students have been taught how to summarize ideas from an article, you can progress to talking about how to read and organize one's readings for ideas. I realize this sounds backwards, so please let me explain. When one is summarizing background literature, whether for a research paper or a thesis, one does not write book reports. Instead, you organize your background research by idea, not by person or book. I teach several steps to help students learn this skill.

First, most students need to be taught to organize their background research section by idea and topic, not by author (i.e., research reviews are not book reviews!). At least for novice writers, each paragraph needs a strong subject sentence about the relevant idea, and the rest of that paragraph should be on the topic of that idea. For example, in her article, Author A may have written about Ideas 1, 2, and 3. In his article, Author B may have written about Ideas 3 and 4, and Author C may have written about Ideas 1, 3, and 4. When the student writes her background research, she should write a paragraph (or more) about Idea 1, referring to authors A and C, then a paragraph about Idea 2 (referring to author A), then a paragraph about Idea 3 (referring to authors A, B, and C), and so on. The subjects of sentences should be the ideas, not the authors. This last maxim is a simple but powerful one: a sentence should normally not begin “Mr. so-and-so who wrote z thinks x”: instead, state the idea (cite the authors).

Second, students can be taught how to become better critical readers of literature in general. Once they understand that they will be organizing the literature by idea, the next step is to teach them how to read critically. In reading critically, one does not simply highlight sentences of interest on a copy of the article: highlighting is an inactive escape from thinking and writing critically. Nor does one make a complete outline of the article—that is, one does not uncritically try to condense the article. Instead, one follows through on the instructions about how to substantively annotate an article.

While reading and annotating articles, the student should begin an index of the ideas she is finding in the literature. Being an old-fashioned person, I make my index by handwriting one idea topic at the top of each sheet of paper. Then, as I am annotating and find someone else who has contributed toward that idea or topic, I list the authors and date of the new reference I have annotated on the appropriate index. If I see what may be an outstanding quotation that I may eventually want to use, rather than copy out the quote I note the page number on my index so that when writing up the topic I may go back and take another look at the quotation.

I find my literature index useful in two main ways. First, it has changed how I read the literature. I am immediately focused from the beginning on figuring out what are the main ideas or topics, rather than reading neutrally. Second, indexing ideas has immeasurably sped up my writing process. My annotations are normally arranged alphabetically by author. My index shows me which annotations to pull together for writing about a topic. Then I put the annotations back into alphabetical order, ready to pull out the next set for the next topic. For example, in writing a lengthy book chapter on archaeological sumpweed or marshelder (*Iva annua*), my index topics included taxonomy, biology, measurements of fruit, evidence for processing, evidence for storage, evidence for use as a food, attempts to grow the crop, and so on. I keep my indexes and continue to find them useful in subsequent research and writing.

One problem that worries students, especially when writing theses, is how to know when enough literature has been read. It is important to teach them that they do not need to find every miniscule reference and that what they are writing is usually not their final word on a subject, but rather their first professional word on that subject. In fact, they may not want to use all of the literature they read: they can save some for later writing. It is important for them to be able to judge whether they have located all the main literature, and here is where teaching them use of the science citation index will help them feel secure in that assessment.

5.2.4 How to Conceive and Pose a Research Question

One's first assignment to conceive of a research question or testable hypothesis is often a frightening experience, and even first- or second-year graduate students may start with little idea of how to begin. Eventually, you want your students to be able to jump right in and ask novel questions that are testable. But to begin with, you may want to supply them with practice in writing a simple, testable hypothesis. You can assign students to use previously published literature to find a research question, encourage them to test their own assumptions or experiences, or you may want to pose a problem and ask them to write a hypothesis to test that problem. I will illustrate these approaches below.

I have learned that I need to teach my students—including graduate students—how to write a testable hypothesis. In fact, before any student is allowed to begin writing a hypothesis-driven paper, I first must approve not only their testable hypothesis, but also the headings (but not yet the data) for a table that would support or not that hypothesis. Additionally, I require the student to include one or more references written to follow the style guide I have chosen. Some students must make two or more revisions before they successfully complete this assignment. I edit student project hypotheses to be as simple as possible, given that the hypothesis-driven paper is just one of many assignments in the class and is constructed to teach how to write this sort of paper rather than demonstrate complexity. Graves and Rutherford (2012) suggest a scoring rubric for grading testable questions.

Over the years that I have given this assignment, I have seen the same two sorts of major problems that students need mentoring to overcome: (1) asking hypotheses that cannot be tested with the data collected, and (2) not using precise enough wording. Even students who conducted standardized interviews often write initial hypotheses that cannot be tested with the data we collected for our group project, despite knowing what questions we asked and therefore what data we collected. In part, this problem is linked to the failure of students to understand the power and preciseness of the wording of a hypothesis.

5.2.4.1 Student-Generated Hypotheses

I supply two examples. In the first case, students collected and shared standardized interviews on botanical knowledge, and the choice of hypothesis was left up to the student. In the second case I supplied the raw data as well as the problem that needed answering about the distribution of artifacts at an archaeological site.

Case 1: Hypothesis Generation Based on Student-Collected Data Here is one example of a second attempt by a student to write a hypothesis for our group project on botanical knowledge. The student said she had conceived of this hypothesis based on a combination of reading previously published literature (secondary research) and considering her own opinion about our primary research.

> If students can free list a variety of trees and vines then they would be more likely to identify them on the plant trail. However, if students did not spend a lot of time outside as a child, then they are less likely to identify them on the plant trail.

My answer was the following:

> We did not measure how much time a student spent outside as a child, so this part of your hypothesis need re-wording. We asked only whether they preferred to be outside. You need to pull your concepts together or just do one. At present you seem to want to test two correlations, neither one conceptually related: (1) those who can freelist more correct trees and vines will also correctly identify more trees and vines (note my wording: wording must be precise). If taking this part of the hypothesis, do you also want to hypothesize about incorrect answers? (2) Those who preferred to spend time outdoors as children will be able to identify more trees and vines on the plant trail than those who only somewhat preferred to be outdoors or did not want to be outdoors? those who did not want to be outdoors? (but then what about those who answered "some")? Please revise and re-submit once again so that I can see through your precise words that your thoughts are clear on what you want to examine and what correlations you think might exist.

Case 2: Hypothesis Generation Based on Data Provided by the Instructor In an upper-level archaeology lab course, I supplied data to the students on the distribution of artifacts that had been collected within gridded 5 × 5 m units on the surface of a plowed field adjacent to a prehistoric Indian mound that had been reduced in size over the years. Students were given the count and weight of each category of artifact from each of 30 grid units. Their assignment was to propose a testable hypothesis that would address the following question: The mounds at the Mulberry site have been reduced in height by plowing. Plowing and slope wash together have spread material outward from each mound. Do the materials collected from the surface east of Mound B support a distribution from slope wash and/or plowing (of Mound B), or does the distribution of artifacts indicate another explanation(s)? If another explanation, what do you think you see?

In making the assignment, I attempted to forestall the common problems I had previously seen by supplying the students with the following notes: Your first deadline will be to turn in a testable hypothesis in the form of an "if…then…" statement, *due* Monday, March 22. This may be a complex statement that includes one or more "given…if…then…." You should articulate any assumptions that underlie your testable hypothesis. One way to do so is to write "Given xxx, if…then…." Your testable hypothesis must be framed in a way that is *testable*—that immediately tells the reader how one could go about testing its likelihood.

Obviously, your first task is to imagine what sort of artifact distribution would support the statement that the artifacts found on the surface east of Mound B are evidence of slope wash and/or plowing from Mound B (and we are *not* trying to separate out slope wash from plowing: we are trying to determine if the artifacts came from the Mound B dirt). Answer the following: If the artifacts on the surface east of Mound B are there from slope wash/plowing, then I would expect to see ____________ (fill in the blank with what sort of distribution you would expect). Other, additional considerations you will need to research and answer in your paper include: what was the surface visibility, what was the collecting strategy, and what are the implications of plowing and whether or not a surface distribution has *any* meaning? What are the potential implications of any of the artifact categories you choose to present?

Here is an example of a student's first hypothesis attempt:

> If the artifacts that were collected on the surface were pulled down from Mound B due to slope wash and plowing, then I would expect to see type collection artifacts that would be characteristic of the time period that the mound was occupied during and I would also expect to see evidence of activities, such as feasting or other special events, that were common on mound sites.

My reply, in essence, was the following:

> As I said in class, these artifacts have been counted and weighed, but not yet analyzed, so you are unable to hypothesize about activities. Your hypothesis must be about the distribution of artifacts. The second part of your hypothesis is stated in a way that cannot be tested. Additionally, you seem to assume that any artifacts from the mound would be from activities on the mound, yet in class I showed you that mound layers often are constituted of midden (trash mixed with dirt) from elsewhere/elsewhen on the site. Furthermore, are you assuming that the ground to the east of the mound had never been used —that no artifacts could be there unless they came from the mound? Finally, you use terminology from the form ("type collection") that makes no sense to the audience: wording on a lab form is not necessarily used in the write-up. The word "site" is also mis-used.

By now, you may be asking yourself what *would* be a well-written, testable hypothesis that addresses the problem I set for the students. "If the artifacts recovered from the surface of the plowed field to the east of Mound B had originated from downward plowing and/or slope wash from the mound, then I would expect to see the most artifacts near the mound and steadily decreasing numbers of artifacts as I moved away from the mound." Although this is a very simple hypothesis, from my experience it is one that is difficult for most students to conceive without mentoring and revisions. What I like about this data set is that the artifact distribution does not fit this model, effectively requiring the students to then propose a new hypothesis to explain the distribution that does occur.

In this particular upper-level archaeological laboratory class, I assigned a second data set with a problem that required the students to conceive of a testable hypothesis based on ideas and principles from the assigned literature on foodways (e.g., Johannessen 1993) as applied to analysis of archaeological pottery sherds. I gave each student a pair of short, 3–6-page chapters with preliminary analyses of archaeological sites in Arizona. The pertinent data for the students were the count of different types of vessels (bowls versus jars, fancy versus plain) from each site and the archaeologists' interpretations of each site. I challenged the students to use a foodways perspective to evaluate the published interpretation of each pair of sites. This assignment is more difficult than the first because the student had to figure out how basic information about the pottery vessels could help to evaluate how a site functioned, based on reading previous foodways studies that had examined pottery elsewhere.

To summarize, you can provide students with practice and mentoring in how to write testable hypotheses. You may want to start by providing not only the relevant background readings, but also the problem itself, before moving on to ask students to propose a hypothesis that tests more abstract questions (e.g., how can a foodways framework or approach inform an archaeologist about the function of a site). From my experience, it is often the first- or second-year graduate students who have more difficulty with these assignments than do undergraduate students because the graduate students try to incorporate complex relationships that cannot be examined with the data collected.

Working with a common class project affords several advantages in teaching students about proposing testable hypotheses. A common project provides a common overall topic (e.g., ecoliteracy) yet still allows each student to pursue his particular interests or strengths in deciding what hypothesis to examine. However, a project needs be neither large nor multiyear: it may be as simple as sharing a data set as in my example of the Indian mound, whether an imaginary one or an actual data set. A growing number of data sets and case studies are posted online for use in the classroom (e.g., Coffman and Riggs 2006; NCCSTS 2013) Using a group project allows for peer teaching. At least some students will independently propose the same hypotheses for their papers. While viewing the end-of-semester presentations, students frequently comment on how differently the other students handled examination of the same hypothesis—finding different background research, collating data differently, and even reaching different conclusions: an excellent teaching/learning moment!

5.2.5 How to Test or Support the Research

Testing a hypothesis begins with proposing a testable hypothesis with precise wording. Equally vital is teaching the students how to construct tables that support (or not) a hypothesis or statement. Just as students do not learn how to properly cite sources solely through reading articles, neither do they learn how to construct good tables (and properly cite them) through reading articles. I devote class time to teaching students how to choose what data are useful, how to record that data, and how to present data in a table. I have included these discussions as part of a project "how-to," but I have also made separate table-construction assignments. Again, it is amazing to see how painful and difficult students find such assignments, supporting my belief that making good tables is a skill that is not intuitive and needs to be taught.

Tables, even when they are inventories, should be organized and presented to convey information at a glance. A table is not meant to illustrate an important point on its own, leaving interpretation solely to the reader: thus, one should never write "See Table 3". Instead, the author needs to write the point that she wishes to convey, and then cite the table that supports that point. In other words, throughout a research paper ideas need to be clearly stated, and all ideas need attribution—citing either the researched sources of ideas (and list sources in the references cited section) or citing the table that supports your idea.

The title to a table should be descriptive. The table must be easily read, with clear, unambiguous information. Terms, abbreviations, and measurements in a table should be clearly defined through the use of footnotes within the table. The column and row categories chosen should be relevant to the table's objectives. Raw counts are rarely useful in a table; rather, percentages are better at conveying relative importance of various categories. Any time you do give percentages in a table, you must also give the total from which each percentage was derived. All numbers or fractions must be given at the same level, and that level should indicate your level of measurement accuracy. For example, in the same column I would not give one answer as "45.32" and in the next row an answer of "10": instead, the second answer should be "10.00," indicating the level of accuracy to which it was measured. To help keep a table clean, any notation that applies to all items in a column or row should be in the heading rather than next to the item (e.g., do not write 10.0 %, 12.5 %, 0.5 %, but rather put "percent" in the heading).

In my upper-level archaeological lab course, I assign an exercise to construct two tables from raw (imaginary) data that I supply, following a style guide that I also supply. Each table presents the students with different table-making problems to solve. In the assignment, I supply the students with a paragraph of background information, the statement the table should be constructed to illustrate or support, along with lists of raw data. When I return the graded homework, I give the students the tables I constructed. I grade the students' tables on (1) how well the table makes the point, illustrates the idea, and includes necessary information; (2) the visual aspect of presentation; and (3) following the assigned style guide.

5.2.5.1 Assignment to Construct Tables

For the Table 1 assignment, the following background information is given: Middle Woodland seed assemblages at villages in the Midwest are characterized by an abundance of the starchy seed assemblage (maygrass, chenopod, erect knotweed). Maize is extremely rare. Oily seeds such as sunflower and sumpweed may be present. Weed seeds are present, but not especially abundant.

The assignment is to construct a table that supports the following statement: "The botanical remains from the Norton site (11ST93) typify the botanical assemblages found at other Middle Woodland village sites in the midcontinent (Table 1)." As you can see from *my* attempt to construct this table (Table 5.1), this is not an easy assignment and the table can be quite complex. However, all the data I supply to the students can be used.

The second table I assign requires footnotes and the students need to figure out that all the data I give are not needed or else need to be categorized and condensed in order to illustrate the idea. Again, I give the students raw counts by category by site, and some background information as follows: Middle Woodland lithic assemblages in Illinois and Missouri are characterized by the abundance of blades (made from prepared cores). These are often made from exotic (nonlocal) rather than local raw materials (chert is one type of raw material that can be identified as local or exotic in origin). Using the data given below, compose a table(s) that illustrates/sup-

Table 5.1 Seed counts from the Norton site (11ST93)

Identification	Percent
Cultivated (n = 3,811)	*Percent of cultivated*
Starchy seeds	*96.9%*
Maygrass	48.9
Chenopod	40.5
Erect Knotweed	7.5
Oily seeds	*3.2%*
Sumpweed	2.3
Sunflower	0.9
Weeds (n = 31)	*Percent of weeds*
Purslane	48.4
Ground cherry	22.6
Nightshade	12.9
Redmaids	9.7
Poke	6.5
Total cultivated (*n* = 3,842)	99.2
Total weeds (*n* = 3,842)	0.8

ports the following statement: "The Middle Woodland occupations in the Stillwater Valley did not fully participate in Illinois Valley exchange networks: nonlocal cherts are rarely found at these four village sites, and despite the presence of a few blades, no established blade industry is evident (Table 5.2)."

My table not only illustrates the statement, but also can be used to demonstrate that although exotic materials were rare at these sites, a disproportionate frequency of exotic materials was used in the blade industry.

Another aspect to teaching students about presenting data is how to collate data, something I find easiest to do within the context of my class-based projects. I talk about how I construct my working or raw data tables, from which I will construct finished tables such as Tables 5.1, and 5.2, to illustrate statements in my paper. One concept that needs to be articulated to students is that the terminology on your data collection form or even the categories of collection do not necessarily directly translate into categories or terminology used in the tables or paper. For example, archaeologists in the southeastern USA routinely count and weigh all ceramic sherds (vessel fragments), but analyze (collect data on attributes) only those above a certain size. Thus, the laboratory form divides sherds by size, yet a table giving count would not necessarily do so.

5.2.6 How to Structure and Present Research

Both major and minor class assignments can be used to provide students with practice in writing research, just as assignments can be made for publically presenting research. For many students, the prospect of writing or publically reporting research

Table 5.2 Summary of lithic artifacts from Stillwater Valley sites

Site name	Tools[a]		Debitage[b]		Blade industry[c]		Lithic total	Blade total[e]	Chert total[f]
	No.	%[d]	No.	%[d]	No.	%[d]			
Cracker (11ST21)	43	4.7	1,022	0.3	16	50.0	1,081	1.5	1.2
Barrel (11ST89)	65	1.5	2,350	0.1	12	16.7	2,427	0.5	0.2
Norton (11ST93)	92	0.0	3,473	0.1	15	33.2	3,580	0.4	0.3
Bilbo (11AF213)	39	0.0	775	0.9	4	25.0	818	0.5	1.0

[a] Bifaces, points, scrapers, and hammers
[b] Flakes, shatter, and cores (not including blades or prepared cores)
[c] Blades and prepared cores
[d] Percent that is nonlocal chert
[e] Blade industry (blades and prepared cores) as percent of total count of lithic artifacts
[f] Nonlocal chert as percent of total count of lithic artifacts

is overwhelming: Your job is to demystify the process, ease student fears, and break requirements into manageable steps. Additionally, you may help students learn to recognize the elements of a good research presentation by assigning them to analyze or compare other peoples' research reports. In the following section I begin with analysis of reports before talking about assignments to write or present reports. The classic route is to assign a written paper or report, and I will demonstrate using one major and one minor assignment I have given. You may also experiment with assigning alternative ways for students to report on their research, as I have already mentioned in talking about my YouTube assignment.

5.2.6.1 Analyzing Research Reports

Are there requirements or expectations for the sorts of analytical reports you will write in your field? For example, what would you wish a report to include so that you could replicate a particular method it uses, or so that you could compare its data with your data? Has the report been written so that you are able to evaluate the conclusions? Let us say you are planning on writing a thesis that includes analysis: What is expected? Any one report may include an introduction, a theoretical framework, descriptions, definitions, tables, figures, quantifications, interpretations, and different sorts of analyses. It will have specific questions it attempts to answer.

One exercise I have used with great success among undergraduate and Master's students who are preparing to write a thesis is to require each to critically review selected elements of two older theses. The theses I choose for each individual student ideally represent a well-written versus a poorly-constructed example, but I also look for theses that are based on a similar literature, theoretical approach, or geographic area of the current student's research. I provide a questionnaire to fill out about each thesis. My questions begin with analysis of the Table of Contents (are headings and levels complete and in agreement?). I place stress on the Introduction (How many paragraphs from the beginning is the purpose of the thesis given? When is the data set outlined? Does the Introduction provide a clear road map to the rest of the thesis? Is enough background outlined so that the reader has a clear understanding of the scope of the problem and what topics should be covered in the Background Research chapter?). Similar questions are devised for each succeeding sort of chapter (e.g., Background Research, Methods, Results, Discussion, Conclusions). Some questions crosscut each chapter (Does the chapter begin with a road map to the chapter? Is the flow of presentation logical and clear? Does the chapter end with a summary of what was covered, and then a brief outline of what will be covered in the next chapter? Are headings used to help guide the reader?). The final question asks the student to justify their ranking for the quality of the thesis. Unvaryingly, the students remark on how much they learn about the mysteries of how to construct a thesis from this assignment.

Assigning a Minor Report One minor writing exercise that I like to assign is for students to write a short but factual position paper for which I have supplied instructions and a grading rubric. For example: "You are an intern in the office of a state senator. She has asked you to write her a short 3–4 page Briefing Paper on whether or not genetically engineered food should be specially labeled." The day this assignment is due, the students are well prepared to discuss the issues in class. Coffman and Riggs (2006) outline a method for assigning a web-based inquiry project for which students need write very little in order to demonstrate mastery of research skills.

Minor Report Assignment Example: "Should Genetically Engineered Foods be Labeled?" Your position paper needs to include the following elements (not numbered in your paper):

1. Short introductory paragraph briefly explaining what is meant by genetic engineering (so a state senator could understand).
2. A second introductory paragraph setting out the basic issues connected with labeling of genetically engineered foods and the players involved (the stakeholders who are for or against such labeling or who would be involved in implementation of labeling). *You will be graded on how many of the different issues and stakeholders you identify.* This is the section that is often inadequate, so do your research thoroughly before writing this. This may become two paragraphs: one on the stakeholders who will tend to be against labeling, and one on the stakeholders who will tend to be for labeling.
3. Pros or arguments *for* labeling GE foods. Include at least five substantiated facts for which you demonstrate good understanding.
4. Cons or arguments AGAINST labeling GE foods. Include at least five substantiated facts for which you demonstrate good understanding.
5. A short summary statement that draws together the basic issues, the players, and the positions they are likely to take so that the senator will be prepared for the upcoming debate.
6. Extra to the 3–4 pages of writing, include a References Cited section. You must include at least one printed source, and you must use the assigned style guide.

Assigning a Major Report The individual hypothesis-driven reports the students write about our group projects are a major intellectual and conceptual step for the students. To allay their fears about whether or not to risk taking my class when they are lower-level students with no background in anthropology or in botany, I promise that I will guide them through all the methods of the project and how to write a scientific report. I prepare extensive handouts and we talk in class about the elements required in their reports (Introduction, Background Research, Methodology, Results, Discussion and Conclusions, Acknowledgments, References Cited). I teach them how to collect data, how to write hypotheses, how to make tables, and how to use the assigned style guide. In other words, how to conduct research is a major learning objective for the course, and a fair amount of class time is devoted to learning and practicing this process.

I divide the research process into manageable sections with step-wise due dates that help lead each student toward a finished product—the same sorts of sections illustrated throughout this chapter. I admit that my teaching method is time intensive for me because I mark student assignments both for substance, grammar, and adherence to the style guide. I return their marked, completed paper to them promptly, and they are required to revise and resubmit, and I mark the paper once again. I consider my time well spent because the students' reviews of the course remark favorably on the research, writing, and ethnographic skills they have learned. Each student leaves the course with a professional certification in human subject research (CITI 2013), has gathered actual data, and not only has written a hypothesis-driven paper based on actual research, but also has rewritten the paper so that it is polished. I advise students to keep their papers in their portfolio and to submit them as their writing example for graduate school or job applications.

5.3 Teaching Academic Integrity in Research

Academic integrity is not a series of separate issues, or even a one-time class topic, but rather a practice that should permeate all assignments and academic work (e.g., COSEPUP 2009, p. xvi), and that should be modeled by the instructor. The National Academy of Sciences delineates three categories of research misconduct: (1) misconduct in science (e.g., plagiarism or falsification); (2) questionable research practices (e.g., inadequate research records); and (3) other misconduct (e.g., sexual harassment, breaking regulations) (NAS 1992; Swazey et al. 1993). Teaching academic integrity is situated in and follows from other content and skills taught in class. The best way to help students become practitioners of academic integrity is to provide clear guidelines in assignments and syllabi; to hold students accountable; to model what you preach; and to instruct students in how to cite, quote, and paraphrase (Craig et al. 2010). Two academic integrity issues that should be included in instruction at all levels are plagiarism and fair use copyright issues, both of which link to how to properly cite sources. Additionally, instructors should introduce students to the appropriate professional codes of ethics.

A great deal of material to help you in teaching or discussing research integrity is available on the web. For example, the AAAS produced a series of five short videos on integrity in scientific research (AAAS 1996). Actors play out dilemmas, but the dilemma remains unsolved to allow students to express their opinions on what the actors should do. Begin your web search by checking for teaching resources from scientific oversight organizations, such as AAAS (2000) and the NIH's Office of Research Integrity (ORI 2013).

In the following section, I begin by discussing methods for engaging students with professional codes of ethics. I then briefly discuss teaching ideas for plagiarism, copyright fair use, and proper citation of sources.

5.3.1 Professional Codes of Ethics

Nearly every profession has formulated a professional code of ethics, and many of these are available on the web (e.g., CSEP 2011). In some professions, such as engineering or medicine, breaking the professional code of ethics may result in loss of your license to practice that profession. In many other professions, such as anthropology and various biological professions, the codes of ethics are used for teaching professionalism rather than for adjudication. Through the years, I have used a number of different classroom exercises or assignments to engage students in thinking about the appropriate professional codes of ethics. These assignments can range from 5 min of class time to much larger investments of student effort.

Sometimes I initially assess the general thoughts of the students by assigning a professional dilemma written in a few sentences on a piece of paper to pairs of students in class. After 5 min, I ask each pair in turn to state their assigned dilemma and how they would handle the situation. This idea of "minute dilemmas" was formulated by Will McClatchey. For example, a dilemma could be: "You are gathering information on plants used in rituals among a remote tribe. They have told you that they are holding a secret ritual but you are not invited. Later that night you unintentionally stumble upon where the ritual is taking place. Do you conceal yourself and watch the ritual?" I find that most students give well-reasoned answers, even before we hold any classroom discussion of ethical behavior.

Rather than simply ask students to read a professional code of ethics and come to class prepared to discuss the code, I find it productive to assign two differing codes of ethics and a short series of questions. On the day the answers are due, the class is ready to discuss the two codes of ethics. My favorite pair to compare and contrast is that from the American Anthropological Association (AAA 2012) and the International Society of Ethnobiology (ISE 2006). The former is framed in terms of responsibilities, including responsibilities to students; the latter takes into consideration international declarations, is heavily weighted toward indigenous rights, and was originally formulated as a list of shared societal principles. The questions I ask are quite simple: What do you like about each code, how are they similar, and how are they different.

At the high end of the spectrum in class time devoted to research integrity are composing or "role-acting" case studies. In teaching courses on anthropological ethics, I have assigned students who have gathered two original case studies by interviewing other people to present and analyze the dilemmas based on the AAA code of ethics. Will McClatchey invented a scenario for his students to role act all semester (for example, loggers who want to buy timber from a remote tribe, who in turn want to build a school for their children, plus government aid workers who work with both sides). He provided students with written-out roles and hidden agendas, and allowed the scenario to develop throughout the entire semester.

5.3.2 Plagiarism and Copyright Fair Use

I have learned not to assume a student of any level understands what constitutes plagiarism. Survey of students in undergraduate entry-level science courses reveals that even students who may be able to define plagiarism cannot necessarily distinguish plagiarism in examples (Nelson et al. 2013). When doctoral candidates and their faculty were questioned about ethically questionable behaviors in 99 of the largest US graduate departments in chemistry, civil engineering, microbiology, and sociology, "the significant rate of reported student plagiarism points to the role faculty need to play in instructing *even graduate students* [emphasis added] about appropriate attribution standards" (Swazey et al. 1993, p. 550). The majority of college presidents surveyed in 2011 say that student plagiarism is on the rise, and 89% of those presidents believe the use of computers and the Internet play a major role (Parker et al. 2011).

I have learned that if I want students to not plagiarize, I need to begin by defining plagiarism and then asking students to judge scenarios. One quick hands-on lesson is to assign student pairs 5 min in class to assess whether examples you give constitute plagiarism or not. Likewise, you can assign pairs of students to paraphrase an assigned text and properly cite the source: other pairs of students may evaluate the results.

The ease with which material (written word, illustrations, sound recordings) seems freely available digitally or on the Internet makes it critical that instructors spend class time in clarifying both plagiarism and copyright fair use. Thanks to McGrail and McGrail (2010), I have come to realize that more time spent on fair use within copyright law will help clarify the issues of making a video (e.g., Center for Social Media 2008) that will be viewed publically, such as the video YouTube slide show I assign students in lieu of an end-of-semester PowerPoint presentation (Wagner 2010b, 2011a, b). The US Copyright Office (2009) provides a document on copyright basics, and YouTube provides copyright basics and community guidelines, as well as terms of use and a privacy policy (YouTube 2011a, b, c). Available through Creative Commons, Georgia K. Harper (2007) has posted a copyright crash course that concludes with a tutorial quiz that can be assigned in class.

5.3.2.1 Proper Citation

In my experience, it is difficult to teach students how to use a style guide that differs from whatever style guide they have used in the past for writing references they have cited. An eye for detail and an understanding of the structural elements within a citation are required for a person to be able to properly follow any style guide. Students want to rely on a computer citation program, yet without the ability to recognize the structural elements in a citation, they cannot properly use such a program. I consistently find failure on the part of students to recognize citation problems when I require students to use my grading rubric to grade the homework of two other assigned students. To practice use of my selected style guide, I hand pairs of students in class a printout of the style guide I use (SAA 2013), and a short stack of various citation problems—a chapter in an edited volume, a multi-authored article, and so on. As each pair works their way through writing out the citations, I walk around class and make individual evaluations of their efforts.

Even more difficult is helping students understand how to properly and fully cite sources derived from the web. Without supervision, a student's solution is to simply list the URL of the source, a practice that is modeled when instructors also use a URL shorthand to label web-derived illustrations within their class PowerPoint presentations. I have devised a new exercise that can be used as homework or assigned to pairs of students in class, in which I supply a web link and the students are challenged to write the full citation following my preferred style guide (Wagner 2013). My solutions are subsequently supplied, and the students are asked to verbalize how and why their citations differ from mine. One concept they do grasp is the need for their citation to include the date of viewing, given that non-published web content may be changed at any time.

5.4 Conclusion

Experiential education by student participation in research projects has demonstrated value in encouraging young professionals (Craney et al. 2011; Thiry et al. 2011). But the number of students far exceeds capabilities for placement into full-blown research experiences. In this chapter, I propose methods for incorporating research skills into nearly any class. The assignments may take as little as 5–10 min or may be expanded to span parts of an entire semester.

The philosophy I encourage here is to teach, practice, and model research skills. Research skills are not necessarily learned by observation (Kirschner et al. 2006), but need to be taught, practiced, and critiqued. I have come to realize that to do so, I must be willing to reduce topical content in my courses to make room for teaching and practicing research skills. Reinforcement of research skills should be at multiple levels, from lesson organization, to use of learning objectives and grading rubrics, to consistency in how the instructor models research standards. Research skills are useful for every student, regardless of their major or later interests in life.

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Chapter 6
Aligning Plant Identification Curricula to Disciplinary Standards Through the Framework of Student-Centered Learning

Sunshine L. Brosi and Ryan D. Huish

6.1 Introduction

The process of identifying and classifying plants can be challenging to students who lack the framework or desire to apply these skills to the natural world and in a broader cultural context (Cooper 2008; Łuczaj 2009; O'Brien 2010). We propose that a shift of learning objectives in plant identification curricula from baseline content knowledge to emphasize broader interdisciplinary competencies and applications, all within a paradigm of student-centered learning, can help reveal this framework and desire that seems to be lacking in such students.

Plant identification courses have conventionally been taught in a teacher-centered approach where instructors present plants to their students in the field or classroom and list characteristics of the plant or plant family, which students are later required to recall for an exam. Assimilating the vast amount of names and characteristics can be overwhelming to even the most dedicated student. Furthermore, when course objectives are sought through a traditional, teacher-centered approach it can exacerbate the shortcomings of rote learning, such as decreased long-term retention and waning student attention and interest. Fundamental learning objectives can be approached while improving assimilation of information by students with varied memorization styles, and promoting student interest by encouraging greater student responsibility for and control of the learning process (Barr and Tagg 1995). Student-centered approaches help develop core competencies as they stem from an understanding of student needs to develop higher-ordered learning skills, and require active engagement. One of the main resulting aspirations is to cultivate independent learning skills, which students need to gain for lifelong, self-motivated learning and application (Brewer et al. 2011).

S. L. Brosi (✉)
Department of Biology, Frostburg State University, 101 Braddock Road, Frostburg, MD 21532, USA
e-mail: slbrosi@frostburg.edu

R. D. Huish
Department of Biology, Hollins University, Roanoke, VA, USA

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We provide examples of student-centered activities to increase engagement and appreciation of plant identification through methods familiar to students in other contexts while aligning plant identification objectives with the disciplinary standards of biology, ethnobiology, and plant biology to promote development of applicable core competencies. Some of these activities include student-led field presentations of plants, authentic research, and service learning, while incorporating several platforms for introduction and review including discussions on interdisciplinary connections, interactive problem solving and games, creative mnemonics, and online tools and mobile applications. We describe methods that we have variably used in several courses, namely, Dendrology, Plant Taxonomy, Economic Botany, Plant Biology, Plants and People — An Introduction to Ethnobotany, and Plants of Virginia, which we hope are transferable to a great diversity of classroom settings, students, and instructors.

6.2 Aligning Plant Identification Pedagogy with Disciplinary Standards

Central to a transition from rote memorization of plant names and characters to applicable skills within plant sciences is the role of disciplinary standards. These standards, sample learning objectives, activities, and assessments have been established and evaluated for general biology courses. However, resources and publications framing learning objectives, activities and assessments around established disciplinary standards within plant identification specifically are limited.

The American Association for the Advancement of Science (AAAS) and the National Science Foundation (NSF) have recommended standards in biology education in the publication, *Vision and Change in Undergraduate Biology Education: A Call to Action* (Brewer et al. 2011). They strongly advocate—with substantial support—the rethinking of biology curriculum to focus on student-centered learning in order to maximize learning outcome and core competencies, and to improve biological literacy and communication in this changing and increasingly interconnected world. One of the goals behind the publication was to engage the biology education community in the active implementation of change (Brewer et al. 2011). Two of the biology sub-disciplines that answered this "call to action" were ethnobiology and plant biology. Within the framework of interdisciplinary awareness, the field of ethnobiology, through the Open Science Network in Ethnobiology (OSN), adapted their own *Vision and Change for Undergraduate Ethnobiology Education in the USA: Recommended Curriculum Assessment Guidelines* (McClatchey et al. 2013). The publication provides ethnobiological core concepts and training areas adapted from *Vision and Change*, and focused within the context of this subdiscipline. The American Society of Plant Biologists (ASPB) and the Botanical Society of America (BSA) joined in adapting the *Vision and Change* to plant biology in their document, *Core Concepts and Learning Objectives in Plant Biology for Undergraduates* (Archer et al. 2012). These publications are valuable resources in aligning plant identification pedagogy with disciplinary standards.

Traditionally, plant identification courses focus on transmitting knowledge to students through identifying and naming plant species. These skills fall within the lower-level learning objectives of Bloom's Taxonomy, namely acquiring knowledge through memorizing facts, naming, describing, and identifying. While knowledge and comprehension are central skills to learn in plant identification coursework, this does not paint the whole story, nor do they extend completely towards building the core competencies of a plant science or biology education. Developing competencies in the abilities to tap into the interdisciplinary nature of science, and applying the process of science requires higher-order skills of critical thinking such as application, analysis, synthesis, and evaluation (Bloom 1956). Plant identification courses, therefore, need to expand traditional objectives of plant identification knowledge to include higher-order learning.

In Table 6.1, we have provided examples of plant identification learning outcomes and objectives with the corresponding core concepts and competencies—as defined by the broader disciplinary standards in biology, ethnobiology, and plant biology—to which they contribute. Here we have defined learning outcomes as "broad goals describing what learners are supposed to know or be able to do (knowledge, skills and abilities) after one or more learning interventions" (McClatchey et al. 2013). Because learning outcomes are stated in general terms, they are not measurable (Jonassen 1997); to measure learning outcomes, they need associated assessments such as learning objectives (Osguthorpe et al. 2010). These learning objectives were written in the framework of Bloom's taxonomy with corresponding levels of integration of learning from lowest to highest: knowledge, comprehension, application, analysis, synthesis, and evaluation (Bloom 1956, rev. Anderson et al. 2005). The associated core concepts or competencies are included as defined by the respective organizations representing the discipline: Biology (AAAS) (Brewer et al. 2011), ethnobiology (OSN) (McClatchey et al. 2013), and plant biology (ASPB–BSA) (Archer et al. 2012).

6.2.1 Sample Learning Activities

Our learning activities can be framed within three major learning outcomes: specialized knowledge of the taxonomy and phylogeny of regional plants, integrated understanding of regional plants' interactions with other organisms—including humans—and the environment, and application of plant identification concepts and skills to problem solving and the process of science. Many of the specific learning activities that we have incorporated into our plant identification curricula are summarized in the learning objectives listed in Table 6.1. We only expound on several of them here, including field presentations of plants by students and active participation in research and service-learning projects. Field presentations of plants by individual students increase students' responsibility over the learning process and provide opportunities for public speaking and scientific communication. Problem solving and familiar interactive games can be adapted to assist in breaking the monotony of memorization, increase interaction among students, and improve as-

Table 6.1 Examples of plant identification learning outcomes and objectives with the corresponding disciplinary core concepts and competencies to which they contribute

Learning outcomes	Learning objectives assessment (using Bloom's taxonomy levels of integration)	Core concepts in biology, ethnobiology, and plant biology	Competencies in biology and ethnobiology
Specialized knowledge of the taxonomy and phylogeny of regional plants	Identify particular plants by their scientific and vernacular names. (Knowledge)	Diversity (OSN)	Taxonomy (OSN)
	Distinguish between diverse regional plants at various taxonomic rankings, including division, family, genus, and species. (Comprehension)	Diversity (OSN)	Taxonomy (OSN)
	Diagram the phylogenetic relationships and morphological characteristics of regional taxonomic groups. (Comprehension)	Evolution (AAAS, ASPB–BSA)	Ability to tap into the interdisciplinary nature of science (AAAS)
		Diversity (OSN)	Taxonomy (OSN)
		Change (OSN)	
	Construct a written, indexed dichotomous key distinguishing species using correct key formatting, terminology, and morphological characteristics. (Synthesis)	Diversity (OSN)	Taxonomy (OSN)
	Compile all necessary information and material to create mounted and fully labeled herbarium specimens. (Synthesis)	Diversity (OSN)	Taxonomy (OSN) Fieldwork skills (OSN)
Integrated understanding of regional plants' interactions with other organisms (including humans) and the environment	Associate various plants with particular ecosystems and roles they play within that system. (Comprehension)	Systems (AAAS)	Ability to tap into the interdisciplinary nature of science (AAAS)
		Connections (OSN)	
		Ecosystems (ASPB–BSA)	
	Explain how regional plants are used and influenced by people and other organisms. (Comprehension)	Systems (AAAS)	Ability to tap into interdisciplinary nature of science (AAAS)
		Connections (OSN)	Ability to understand the relationship between science and society (AAAS)
		Ecosystems (ASPB–BSA)	Bridging skills (OSN)

Table 6.1 (continued)

	Apply plant identification skills to broader social and ecological implications through service learning opportunities. (Application)	Systems (AAAS)	Ability to tap into interdisciplinary nature of science (AAAS)
		Connections (OSN)	Ability to understand the relationship between science and society (AAAS)
		Ecosystems (ASPB–BSA)	Bridging skills (OSN)
	Compile and communicate (written and oral) detailed species descriptions including nomenclature, morphology, ecological and ethnobotanical/zoobotanical characteristics. (Synthesis)	Systems (AAAS)	Ability to tap into interdisciplinary nature of science (AAAS)
		Connections (OSN)	Ability to understand the relationship between science and society (AAAS)
		Ecosystems (ASPB–BSA)	Taxonomy (OSN) Bridging skills (OSN)
	Create concept maps—and critique concept maps of peers—to form multiple-level connections between course concepts. (Synthesis and evaluation)	Systems (AAAS)	Ability to tap into interdisciplinary nature of science (AAAS)
		Evolution (AAAS)	Ability to understand the relationship between science and society (AAAS)
		Connections (OSN) Change (OSN) Ecosystems (ASPB–BSA) Evolution (ASPB–BSA)	Bridging skills (OSN)
Application of plant identification concepts and skills to problem solving and the process of science	Determine the identity of unknown plants using dichotomous keys and knowledge of plant morphology and taxonomy. (Evaluation)	Diversity (OSN)	Taxonomy (OSN) Field skills (OSN)
	Assess characteristics of a plant community—including species richness and relative species abundance—to help solve ecological restoration problems. (Evaluation)	Systems (AAAS)	Ability to tap into interdisciplinary nature of science (AAAS)
		Connections (OSN)	Ability to use quantitative reasoning (AAAS)
		Ecosystems (ASPB–BSA)	Taxonomy (OSN) Field skills (OSN)
	Formulate and test hypotheses on plant phenological associations to climate change. (Evaluation)	Systems (AAAS)	Ability to tap into interdisciplinary nature of science (AAAS)
		Connections (OSN)	Ability to use quantitative reasoning (AAAS)
		Ecosystems (ASPB–BSA)	Taxonomy (OSN) Field skills (OSN)

similation of information for students with varied learning styles. Presenting plant identification within a context of historical and cultural uses of plants by people connects plants to societies and economies and improves relevancy and comprehension. Further exercising the students' plant identification skills in authentic research and service-learning projects facilitates the broader competency of applying the process of science and the integration of social, environmental, and ethical responsiveness. These sample activities and learning platforms are described in the following sections.

6.2.1.1 Student-led Investigations and Field Presentations of Plants

The field environment is essential for exposing students to live plants in their habitat. Field exposure assists students in plant identification, as they can better understand phenology and diversity within a single species, morphological variation through space and time, developmental stages of the plant, and variations due to such things as insect damage or ecotypes. One student-centered learning approach to plant identification in the field shifts the emphasis from passive absorption of the instructor's presentation of material to the students' active presentations with the objective of students compiling and communicating—both written and orally—detailed species descriptions including nomenclature, morphological, ecological, and ethnobotanical/zoobotanical characteristics. This engages students in a multifaceted "synthesis" of information, one of the higher levels of learning integration (Bloom 1956), and can help contribute to the disciplinary core concepts related to the interconnectedness of living things and their environments, and the competencies related to the abilities to tap into the interdisciplinary and societal connections to science, and taxonomic abilities (Brewer et al. 2011; Archer et al. 2012; McClatchey et al. 2013).

Student-led field presentation of plants is separated into two specific activities. The first activity includes students composing a written description of one or more particular species to which they are assigned. The second part of the assignment is to orally present the species to the class in the field.

To facilitate the written portion of the student's presentation, a species description sheet can be provided for the student to complete for their unique species (Table 6.2). The instructor gives further explanation on the appropriate locations within their field guides, reference books, textbooks, and online resources to find the information required to fill in the description of each species. Though this information can be written and turned in to the instructor, we propose methods for the students to provide the information to the entire class and incorporate technology through online presentation in the form of student-interactive blogs, wikis, and/or mobile flashcard applications. It is important for this written assignment to be due and graded before the day of the presentation as this will help prevent both inaccurate information from being presented and last-minute preparations being made by the student.

Upon arrival at the field location, the instructor describes the specific characteristics of the site including geology, physiographic provenance, ownership, management, previous land use history and other relevant details, and also invites

Table 6.2 Species description

Nomenclature:	Your name	Common name	Scientific name	Family
theplantlist.org				
Classification:	Group	Duration	Habit	Native status
plants.usda.gov				
Leaf characters	Attachment	Arrangement	Complexity	Stipules/estipulate
field guides				
	Shape	Base	Apex	Margin
	Venation	Upper-surface	Lower-surface	Additional traits
Flower characters	Date	Anatomy	Structures	Symmetry
field guides				
	Petal color	Petal #	Stamen #	Carpel #
Species ecology	Habitat	Host plant	Ornamental	Wildlife
eol.org, nativeplantcenter.net				
Species status	Wetland	Conservation	Medicinal	Poisonous/edible
plants.usda.org, natureserve.org, herb.umd.umich.edu ars-grin.gov/duke				

students to discuss additional observations on the site. Along the hike, when the group encounters the first plant, the instructor announces the first identification challenge. It is then the student's responsibility to recognize the plant pointed out by the instructor as the one he/she was assigned and has described in the species description sheet prior to coming to lab. Upon recognizing the plant, the student thoroughly describes the plant to others in the course and facilitates a group discussion on the plant including ways to help remember the name and characters of the plant. This can be a modification of peer-led team learning (PLTL) or "learning by teaching," which involves students concurrently enrolled in the course (Roscoe and Chi 2004; Gafney and Varma-Nelson 2008; Eberlein et al. 2008). Other students in the course can use the species character matrix to quickly fill in the characteristics for the plant (Table 6.3). This allows the students to listen and check boxes instead of writing a significant amount while in the field.

It is essential that the instructor spends a significant amount of time preparing students on how to obtain the information they will need to present, and it is also important to thoroughly evaluate the student's species description and field presentation so that other students do not replicate inaccuracies. However, much of this instruction can be done prior to the lab or lecture using the flipped classroom approach. The structure of individual oral presentation activities requires high student engagement and high attendance rates. When a student is absent, the instructor must be prepared to present the information to the other students or assist them in obtaining the information from their field guides. In addition, students need to be prepared to present in remote locations without cellular coverage or Internet access. One effective paperless solution is to have students create screenshots of their assignment wiki or the web page prior to leaving campus. The instructor must be flexible with the flow of the class to mitigate impacts of absent and underprepared students.

Table 6.3 Sample species character matrix

Character	State	1	2	…	10
Leaf arrangement	Opposite				
	Alternate				
	Whorled				
	Fascicled				
	Solitary				
Leaf complexity	Simple				
	Compound				
Leaf attachment	Sessile				
	Petiolate				
Compound	Palmately				
	Pinnately				
	Bipinnately				
Lobed	Palmately				
	Pinnately				
Leaf margin	Entire				
	Repand				
	Sinuate				
	Crenate				
	Dentate				
	Serrate				
	2X-serrate				
Leaf apices	Acuminate				
	Acute				
	Obtuse				
	Rounded				
	Truncate				
	Mucronate				
	Emarginate				
Leaf bases	Cuneate				
	Acute				
	Inequilateral				
	Obtuse				
	Rounded				
	Truncate				
	Cordate				
	Auriculate				
Leaf shape	Linear				
	Oblong				
	Lanceolate				
	Ovate				
	Elliptical				
	Oval				
	Orbicular				
	Reniform				
	Rhombic				
	Spatulate				

Table 6.3 (continued)

Character	State	1	2	…	10
Condition of the corolla	Apetalous				
	Appetalous				
	Sympetalous				
Number of stamens	Many				
	2X Petals				
	= Petals				
	< Petals				
Symmetry	Radial				
	Biradial				
	Bilateral				
	Asymetric				
Hypathium	Present				
	Absent				
Ovary position	Superior				
	Inferior				
Condition of gynoecium	Apocarpous				
	Monocarpous				
	Syncarpous				
Flower sex	Perfect				
	Staminate				
	Pistilate				
	Monoecious				
	Dioecious				
	Synoecious				
Sepals	#				
	Distinct				
	Connate				
Petals	#				
	Distinct				
	Connate				
Conservation status	Invasive				
	Secure				
	Rare				
	Threatened				
	Endangered				
Ornamental	Yes				
	No				
Butterfly host	Yes				
	No				
Wildlife habitat	Large mammals				
	Small mammals				
	birds				
Wetland indicator	Obl. wetland				
	Fac. wetland				
	Fac.				
	Fac. upland				
	Obl. upland				

6.2.1.2 Field Research Projects Applying the Process of Science

Involving students in field research projects facilitates the development of research skills, such as recognizing problems, understanding research design, formulating hypotheses, data collection, problem solving, and broader research implications. Proper plant identification skills are a methodological component of the field research and are taught within the context of the process of science. Because of the nature of plant identification courses, field research projects cannot be too intense, complicated, or time-consuming, but the right research projects can balance these limitations and also provide meaningful learning opportunities and useful results.

Smaller research exercises that fit into larger research projects can adapt well to these courses, and yet still enable students to participate in the process of science. Research components in plant identification courses not only help to sharpen plant identification skills, and develop research proficiencies, but research activities also increase students' long-term interest in science and understanding of scientific processes (Brewer et al. 2011).

One example of a learning objective we use to apply plant identification skills to the process of science is to assess characteristics of a plant community—including species richness and relative species abundance—to help solve ecological restoration problems as part of an ongoing research project at an ecological restoration site on campus. Another objective is to formulate and test hypotheses on plant phenological associations to climate change by collecting data on events such as leaf emergence in areas predicted to be highly vulnerable to climatic change. These data can be submitted to the National Phenology Network (NPN) (https://www.usanpn.org/) where additional data can be mined to test hypotheses. These projects engage students in authentic research activities using higher levels of learning integration, including "evaluation" (Bloom 1956). They can also contribute to disciplinary core concepts related to the interconnectedness of living things and their environments, and the competencies related to the abilities to tap into the interdisciplinary nature of science, to use quantitative reasoning, as well as taxonomic and fieldwork abilities. Such projects also have the potential to be expanded to develop competencies in modeling and simulation (Brewer et al. 2011; Archer et al. 2012; McClatchey et al. 2013). In some cases, these research activities were presented as problem-based learning exercises, which further emphasize the development of skills requiring discovery and evaluations of a problem, collecting data, and recommending solutions (Allen and Tanner 2003; Waterman and Stanley 1998; Eberlein et al. 2008). Another idea could involve a research module gathering and applying data on invasive species (that were covered in class) for the Nature Conservancy's iMapInvasives research project (http://www.imapinvasives.org/) to help with the strategic management of invasive plants.

6.2.1.3 Service Learning

Service learning projects provide a method for integrating social, environmental, and ethical awareness (Brewer et al. 2011). We focus on service projects that connect the relationship of plants within the environment and help students develop an understanding of societal interactions. Many service projects also have direct conservation implications for rare, threatened, and endangered species. The service projects can take place at the same location, so that progress can be seen over a period of courses. A few examples of the service projects include removal of non-native plants and tree planting.

Garlic mustard (*Alliaria petiolata* (M. Bieb.) Cavara & Grande), an invasive non-native plant species, is toxic to the larvae of West Virginia white butterflies (*Pieris virginiensis*) and displaces native wildflowers on which the butterflies depend (Keeler et al. 2006). West Virginia white butterflies have a global ranking of vulnerable and various ranks of rare, vulnerable or threatened in several states within the USA and provinces in Canada. For the past six years, students in Plant Taxonomy have spent an entire lab removing garlic mustard from a known West Virginia white butterfly site in a state forest in Maryland. As part of this project, data are being collected on changes in herbaceous species and the presence of West Virginia white butterflies in the area.

Eastern hemlock trees (*Tsuga canadensis* (L.) Carrière) are attacked by a non-native insect, the hemlock woolly adelgid, *Adelges tsugae*. Students in Dendrology have planted over 10,000 red spruce (*Picea rubens* Sarg.) seedlings in watersheds where hemlock trees are dying. The watersheds were selected which contain native brook trout (*Salvelinus fontinalis*), a species that depends on coniferous shade in the early spring to keep water temperatures cool (Evans 2004). This project is located in an area where data are being collected through the Maryland Biological Stream Survey so the students will be able to track change over time.

These projects immerse students in service learning activities to apply their knowledge to environmental and ethical action, thus incorporating the "application" level of learning integration (Bloom 1956). These learning activities can also contribute to disciplinary core concepts related to the interconnectedness of living things and their environments, and the competencies related to the abilities to tap into the interdisciplinary nature of science and to understand the relationship between science and society (Brewer et al. 2011; Archer et al. 2012; McClatchey et al. 2013).

6.2.2 Additional Platforms for Introduction and Review

The large amount of memorization inherent in plant identification necessitates varied methods of introducing new plants and reviewing those plants throughout the duration of a course or unit. A focus on relevant connections for students learning plant identification can increase students' initial interest in a plant by linking the plant with other valued aspects of their lives. Connections with plants along with interactive problem solving and games, and various online tools, are platforms for introduction and review as discussed below.

6.2.2.1 Connections for Learning Plant Identification

There is often a lack of relevance of plants to college students' lives, outside of a few common plants. Students often approach a plant with an anthropogenic "what good is it?" attitude. There is often a desire to make a connection with the plant by asking "can I eat it?" or "is it poisonous?" Activities integrating cultural and historical plant roles, sensory connections with a plant, and ecological contexts can allow for interdisciplinary investigations while providing essential relevance and associations for easier memorization.

With the objective of improving competencies of tapping into the interdisciplinary nature of science and understanding the relationship between science and society, we often include ethnobotanical details such as medicinal, food, and other practical uses, and connections to history, festivals, and poetry in the introduction of each plant. Anthropological connections to plants can include culturally relevant dialogue about each plant such as references to popular culture, such as the poison nightlock, a fictional plant whose name was derived from the toxic nightshade (*Solanum spp.* L.) and poison hemlock (*Conium maculatum* L.) in *The Hunger Games* trilogy (Collins 2008, 2009, 2010; Ross 2012).

Knowing and teaching intersensory connections to plants can expand the interaction and associations with the plant at new neural levels, leading to improved memorization. The sense of smell in humans is stronger and more important than some realize (Shepherd 2004). We have an amazing capacity to recognize an incredible amount of structurally diverse volatile compounds and our minds process these olfactory exercises in ways that promote strong connections to memory (Lyman and McDaniel 1990; Zozulya 2001). When it comes to recognizing and recalling some plant identities, the nose knows. For example, the vanilla-scented bark of ponderosa pine (*Pinus ponderosa* Lawson & C. Lawson), the scent of wintergreen leaves (*Gaultheria procumbens* L.), and the unique sweet, spicy smells of spicebush (*Lindera benzoin* (L.) Blume) or sassafras (*Sassafras albidum* (Nutt.) Nees) may be plant scents that people more commonly have associations with, but even plants that do not have strong pleasant smells can still have characteristic odors, especially when the plant parts are scratched or crushed. Sometimes there are common elements of scent within broader taxonomic groups, like the Magnolia family with its characteristic "Ranalean odor" (in reference to an old classification system which included the magnolias in the Ranales). Characteristics that are discernable through the other senses—like the touch of the rough, sandpapery leaves of slippery elm (*Ulmus rubra* Muhl.)—can also help distinguish between similar species, spark students' interest and jog memory. These sensory experiences are natural additions to the field presentation of plants, or plant parts retrieved for classroom use. To help develop intersensory skills, students can be blindfolded and led to a safe (e.g., no thorns or toxins) plant to identify using all their senses except sight. It boosts students' confidence when they can say that they identified a plant blindfolded.

Presenting a plant within the context of the ecosystem is another way to increase relevance and integrate connections between plant identification and other disciplines such as ecology, forestry, wildlife biology, and conservation biology.

Identifying the roles of a plant within the environment and its particular impacts on another species improves understanding of the importance of conservation. Wildlife connections relating green plants to charismatic megafauna or beautiful butterflies and birds introduce stories that facilitate recall of plant names. For example, skunk cabbage (*Symplocarpus foetidus* (L.) Salisb. ex W. P. C. Barton) comes alive in the context of a purgative used by black bears to expel their anal plug after hibernation. Also, garlic mustard (*Alliaria petiolata* (M. Bieb.) Cavara & Grande) is an invasive non-native plant species throughout many regions and is seen only as a nuisance. Eradication of garlic mustard is understandable when students become aware of the plants toxicity to the larvae of the rare West Virginia white butterflies (*Pieris virginiensis*). The decline of eastern hemlock trees, (*Tsuga canadensis* (L.) Carrière), is due to attacks by a non-native insect, the hemlock woolly adelgid (*Adelges tsugae*). Student engagement occurs when this condition is related to detrimental impacts on native brook trout caused by the reduction of coniferous shade and the resultant warming of streams in early spring (Evans 2004). These connections between plants and their ecosystems can easily be modified to specific local environmental concerns to increase relevance and emphasize place-based learning.

Looking at how botanical knowledge is taught and passed down from one generation to another in cultures with strong oral traditions reveals similar methods of learning. The appreciation and valorizing of plants within broader cultural and ecological contexts and the use of sensory cues such as taste, odor, texture, and even audible cues are vital to the way they identify plants and teach their children to identify plants (McLuhan 1962; Hunn 2002; Shepard 1999; Shepard 2002). These methods of effectively passing on information seem to be deeply imbedded into human nature.

6.2.2.2 Interactive Problem Solving and Games

Interactive problem solving and games can help engage students by diversifying learning and review strategies and fostering the development of teamwork while improving peer relationships (Allen and Tanner 2003; Eberlein et al. 2008; Nemerow 1996). Core plant identification problem solving requires students to key out an unidentified plant or plant part. This can be a useful and engaging way to introduce a new plant to students. Groups of students must review characteristics, consult reference books, discuss the plant and then come to a consensus about the plant's identity. This activity can take place within the classroom, or in the field, and promotes competence using a variety of field guides and requires interaction as part of a team.

Beyond this, teams of students can be challenged to create associations to aid in memorization of the plant names. This can be done by translating any morphologically descriptive Latin meanings of the binomial using a botanical Latin field reference book and associating it with distinguishing characteristics of the plant. Another method is creating mnemonics for the identified plant involving a pattern of ideas or associations that assists in remembering the plant names and/or associated information. For example the Latin name of the mountain snowberry (*Symphoricarpus oreophilus* A. Gray) with its white berries can be remembered by thinking of white "oreo filling." Similarly, eastern white pine (*Pinus strobus* Linnaeus) has five needles per fascicle and there are five letters in the word w-h-i-t-e, or Virginia pine has two needles that twist around each other in an embrace and the state of Virginia's slogan is "Virginia is for Lovers." This allows for a creative approach and promotes cooperation among students as they help each other develop mnemonic associations.

The incorporation of traditional, familiar games in a new context provides opportunities to actively engage students and to help them review concepts (Nemerow 1996). The game "I'm thinking of a plant"—a variation of the more familiar "I'm thinking of an animal" —requires one student to think of a plant without revealing it to others. To determine the name of the plant, classmates have to ask "yes" or "no" questions such as "Does the plant have opposite leaves?", "Does the plant have indumentum?", "Does it grow in a riparian ecosystem?", or "Is it used medicinally?" until they get enough clues to correctly guess the plant. The student who first guesses correctly wins the round and gets to think of the next plant. A variation of this game is the familiar "Who Am I" game, where the instructor places a sticky-label with a plant name on it onto the foreheads or backs of students. To determine their identity, students then ask classmates a series of "yes" or "no" questions similar to the "I'm thinking of a plant" game. Students keep track of the number of questions that they had to ask and are rewarded for efficiency. This activity requires the students to critically evaluate which questions are the most beneficial for determinations. Another review game is a plant-focused adaptation of Jeopardy, helpful for relating scientific names, families, and common names, where the answer is worded in the form of a question. For example, students may quiz each other by saying, "poison-ivy," with the other students taking turns responding in different ways: "What is *Toxicodendron radicans*?" or "What is Anacardiaceae?" (the family name), or "What causes contact dermatitis?" These games work well in the classroom but also on hikes or in transit to and from the field because they can be spontaneous, require little or no additional props or planning, and utilize time that otherwise may have been wasted.

6.2.2.3 Online Tools and Mobile Applications

We feel that the essential elements of learning plant identification are routed in field-based activities with live, *in situ* plants and face-to-face interactions with experienced botanists. We emphasize the importance of gaining non-technological interaction within our classes (Bowen 2012). However, we do see technology as a powerful tool for the learn-before-lab method of introduction, for controlled utilization within the class, and for integrated and collaborative review outside of the class. We use technology for providing background information and for consolidating knowledge. In Cathy Davidson's book, *Now You See It: How Technology and Brain*

Science Will Transform Schools and Business for the twenty-first Century (2012), she makes the point that our schools are designed for the last century and that our educational system needs to evolve with the rest of society, who has, through modern technology, adapted to new ways of thinking, learning, and processing information. We agree.

However, technology does come with some hurdles. During one classroom activity, the problem with reliance on technology is introduced with the Apple advertisement that appeared on the back cover of Time Magazine. The new phone was asked "What does poison oak look like?" The phone displayed the image of a taxonomically incorrect plant—eastern poison ivy (*Toxicodendron radicans* (Torr. & A. Gray) Greene) instead of either Pacific poison oak (*T. diversilobum* (Torr. & A. Gray) Greene) or eastern poison oak (*T. pubescens* Mill.). Although this misidentification may have been minor, it emphasized the idea that even Apple and Time Magazine can be fooled into trusting technology too much. Our approach to incorporating technology in the classroom is through guiding students to approach materials online with a critical eye, with an awareness of its shortcomings, and to assist them in determining credible online sources.

Online course management systems allow multiple opportunities for students to share their resources before and after field experiences. The use of course blogs offers an opportunity where individuals and groups of students can add information about the specific plant that they are studying. Blogs can also be used to justify plant determinations with comment sections used for rebuttals or support. In addition, course wikis created for particular field trips, plant families, or other discrete modules provide a collaborative forum for the dissemination of information. This also allows the instructor to check the accuracy of the information the student collected and to ensure reputable sources.

In the traditional approach to teaching plant identification, the student often feels rushed to write down the material presented by the instructor. Course-specific blogs and wikis are a reference location where the students can return to access information. This allows students to "stop and smell the roses" while in the field, instead of anxiously writing down all the required information. Details—such as additional characteristics or ecological connections to the plants—were more frequently perceived by the students as they spent the extra time critically observing, smelling, tasting, writing supplementary notes, taking pictures, and otherwise soaking in the environment and context of the plants.

A variety of free applications are available for smartphones, tablets, or computers, which support the ability to identify plants, obtain field measurements, and to aid in study and review (Table 6.4). Flashcard applications allow the addition of images, text, and audio, with score-keeping capabilities so students can track their progress and learn where to focus their efforts. Many allow for sharing of resources between students and the instructor and interface with social media websites. Facebook, Twitter, and other social media outlets can be used in additional ways to improve student interactions outside of class when mediated by the instructor.

Table 6.4 Examples of mobile software applications or websites for plant identification and field courses

Category	App/website name	Website
Flashcards	StudyBlue	www.studyblue.com/online-flashcards/
Organization	LiveBinders	www.livebinders.com
Plant identification	Leafsnap	leafsnap.com/
	TXRangeID	www.brit.org/rangeplants
	NatureTap	www.greenmountaindigital.com/
	vTree	dendro.cnre.vt.edu/dendrology/main.htm
	NRD trees	www.nrdtrees.org/
	FloraGator	hort.ifas.ufl.edu/floragator/
Data collection tools	Plot hound	silviaterra.com/plothound/
	iMapInvasives	imapinvasives.org
	Nature's Notebook	www.usanpn.org/natures_notebook
	Eco:Map	www.eco-map.de/EcoMap/en/index.html
	Taxonomy	itunes.apple.com/us/app/taxonomy/id409620874?mt=8
	Phenomap	naturalguides.com
Field tools	First Aid by American Red Cross	www.redcross.org/mobile-apps/first-aid-app
	SoilWeb	casoilresource.lawr.ucdavis.edu/drupal/node/902
	My Altitude	itunes.apple.com/us/app/my-altitude/id465262694?mt=8
	EasyMeasure	www.caramba-apps.com/easymeasure/
Navigation	Google Earth	www.google.com/mobile/earth/
	Outdoor Compass	www.gpstuner.com/
	Basecamp	garmin.com
	Trimble Outdoors Navigator	www.trimbleoutdoors.com
	TNP (Terrain Navigator Pro)	maptech.mytopo.com/land/terrainnavigatorpro/?infopg=mobile

6.3 Conclusion

Student-centered activities discussed in this chapter can provide varied opportunities for students to gain fundamental plant identification skills while developing core competencies of biology, ethnobiology, and plant sciences when learning outcomes and objectives of plant identification courses or modules align with disciplinary standards. Our curricular activities supporting these learning outcomes and objectives incorporate student-led investigations and presentations of plants and hands-on problem solving using the process of science and service learning. The integration of various platforms for introduction and review, including discussions on interdisciplinary connections, interactive problem-solving and games, creative mnemonics, online tools, and mobile applications, can further help improve students' accessibility to and synthesis of information, assist in long-term memorization, and diversify modes of instruction and assessment. Success relies on the instructor's ability to take on a mentoring role and to adapt and modify the course in order to facilitate an environment of active and engaged learning.

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Chapter 7
Cultivation of Local Botanical Knowledge or Knowledge of Nature Using Interdisciplinary, Innovative, and Mind/Brain-Based Techniques

Karen C. Hall and April T. Sawey

7.1 Introduction

Botanists and their respective professional societies have lamented the seemingly concomitant loss of interest in and support for botany at least since the early 1990s (Drea 2011; McClatchey et al. 1999; Uno 2009). As a subset of ecological knowledge and similar to it, botanical knowledge is also in decline (Coyle 2005). The lack of botanical knowledge (Wagner 2008; Cooper 2008) and particularly local knowledge of nature sets up a disconnection between people and place and, therefore, may mean the loss of an important survival tool for the future of humanity.

Though we do not always realize this, all humans ultimately depend on natural materials to live. Residents in the USA are largely non-resource dependent. They often rely on natural materials grown, harvested, managed, and manufactured sometimes great distances away from the point of use. This lack of direct experience with materials contributes to the lack of local knowledge. Even if the larger populace could name plants, other organisms, or ecosystems from which the products they use every day are derived, they still would not have the nuanced, in-depth, tacit knowledge associated with daily direct experience with nature in one's own environment. This type of tacit knowledge is often unwritten and undervalued, though it represents the adaptive, dynamic relationships we have with nature and, thus, our coevolution with the systems in which we are embedded (Alexaides 1999; Berkes et al. 2000; Pilgrim et al. 2007; Scoones and Thompson 1994; Scoones et al. 1992). Resource-dependent communities within and outside the USA are supplying our demand for natural materials; as a result, people may believe that knowledge of nature is not necessary. However, as the growth of urban centers continues, cognitive issues associated with reduced contact with nature also arise, owing to what has

K. C. Hall (✉)
Department of Research, Botanical Research Institute of Texas, 1700 University Drive, Fort Worth, TX 76017-3400, USA
e-mail: khall@brit.org

A. T. Sawey
Department of Education, Botanical Research Institute of Texas, Fort Worth, TX, USA

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been termed "extinction of experience," as described by Nabhan and St. Antoine in 1993 and generally popularized as "nature deficit disorder" by Louv in 2005. As experience in nature declines or is no longer present, questions and interest in the local environment disappear and, therefore, our ability to share, adapt, and advance knowledge of our situated place becomes severely limited. Though more specific studies are needed (Atran et al. 2004), there are indications that a lack of knowledge of nature correlates with unsustainable practices that could directly impact survival.

7.1.1 Connectivity and Environmental Education

Environmental education (EE) situated outside of an individual's community may not provide the kind of opportunities for connections to previous knowledge that researchers know are necessary for learning to occur in meaningful, lasting ways. As an example, escalating deforestation in the Amazon, beginning in the late 1970s, led to the development of massive amounts of EE content to help students and adults understand and connect using charismatic megafauna among others in tropical forests around the world. As classrooms focused on forests that experienced such devastation, far-removed children were left with a feeling of despair upon realizing they could do little about this distant problem. Since most had never or likely would never see a rainforest in their lifetime, the despair led to an increased sense of disconnectedness.

A populace disconnected especially from the local natural world of which it is a part may not understand the importance of ecoliteracy for health, resiliency, food security, biodiversity, water/air/soil quality, cultural/personal enrichment, policy, and more. Many researchers lament the challenges associated with continued development and environmental degradation (Rickinson 2001; Pilgrim et al. 2007; Atran et al. 2004). One group of people with the potential to help us understand the challenges are natural resource managers. Because they are dependent on resources, their (assumed) ecological literacy can help protect the resource, though, of course, not all practices are sustainable. The management decisions they make, varied as they are over time and place, positively affect natural systems. Taken as a whole, these practices may be more resilient than a singular reliance on state systems that are devised to protect ecological health (Pilgrim et al. 2007). Local knowledge of landscapes allows for a much more rapid response to sudden perturbations or small changes in the environment as compared to state systems that are better at detecting large-scale shifts. Since state systems also tend to ignore or devalue local knowledge, they neglect this important tool in conservation. Thus, to increase the number of ecologically literate people, even those who are not managing resources, is to also increase our resilience to a level greater than that which is possible through reliance on state systems alone.

However, creating an environmentally literate populace is no small challenge. Coyle (2005) discusses the difficulty in achieving true environmental literacy in students of all levels, stating that after three decades of school-based environmental education, only one-third of adults can pass a basic test of EE. After 35 years of effort in promoting widespread environmental curricula and acknowledging its importance, EE has yet to achieve core subject status (Coyle 2005; Rickinson 2001). Additionally, long-term studies of pro-environmental behavior and/or awareness are virtually nonexistent (Rickinson 2001).

Part of the issue of efficacy (Coyle 2005) in EE may be related to the kinds of knowledge imparted. EE content often focuses on big-picture knowledge of the environment in an effort to change behaviors related to pollution, energy usage, and consumerism. While behavioral change in these issues is desirable, focusing on them alone may not provide enough local and social relevancies to stick. Uzzel et al. (1995) found that students in a 1-week residential program could not bridge the gap between the scientific and familiar understanding of the environment, including the social worlds of which they are a part.

They further had difficulty connecting to problems in the environment, even though they may have directly participated in measuring some symptom of the problem. Rickinson (2001) argues that such an approach does not connect the problem to society (the creators of the issue) nor does it offer an opportunity for challenging societal norms or changing values.

7.1.2 The Role of Traditional Ecological Knowledge in Environmental Education

Studies of natural resource managers and holders of traditional ecological knowledge (TEK) can provide clues in understanding how such knowledge is structured and functions in an adaptive and resilient capacity. Vadala et al. (2007) studied natural resource-related adult professionals and hobbyists in order to ascertain how they became socialized to the environment. They and others point to the importance of guided or unguided play (Caine and Caine 2008; Pert 1997) in creating environmentally literate adults (Vadala et al. 2007). Louise Chawla (1992, 1998, 2001) and her colleagues have studied significant life experiences (SLEs) of modern-day environmental educators and environmental activists for over two decades. These contemporary decision makers (natural resource related adult professionals) and social activists from both studies have SLEs in common. Typically, SLEs were made of multiple outdoor activities taking place over a long period of time.

After analysis of TEK holders largely outside the USA, Berkes (1999) states that TEK is a “knowledge–practice–belief complex” that is “handed down through generations by cultural transmission,” evolving and therefore adaptive. However, if students in EE programs cannot spend enough time outdoors in the same environments repeatedly, how can they understand the subtle changes over time in their own place? If they cannot create this basic connection, how can we expect them to understand greater complexity in these nested natural and human systems? One suggestion taken from work by Berkes et al. (2000) proposes a framework used by TEK holders, later partially analyzed by Pilgrim et al. (2007). After analysis of multiple cultural groups, Berkes proposes that TEK holders analyze ecosystems based on the following social and ecological parameters:

1. Local knowledge of land, animals
2. Land and resource management systems
3. Social institutions
4. Worldview

Each of these four nested dimensions of knowledge is utilized to manage resources needed by the human community over time and space, conveying the "embeddedness of local knowledge" (Berkes 1999) that comprises TEK. These dimensions require knowledge, reflection, critical thinking, and if considered as nonlinear processes, are adaptable and situated to place (both cultural and natural). Inasmuch as these parameters represent a path to intimate connection to place, we propose that they may be used as a scaffolding to include these broad-based recommendations for EE content:

1. **Create experiences in nature.** Although one of the least researched areas of EE (Rickinson 2001), experiences help create opportunities to build the nuanced, in-depth, tacit knowledge associated with ecologically literate people. It is through these experiences (Dewey 1938) within our sociocultural communities (Vygotsky 1978) that we gain and construct new knowledge. These experiences must be sociocultural in nature for optimum learning to occur (Caine and Caine 1997; Rickinson 2001; Vygotsky 1978). A subset of this is creating process skills. Particularly in botany, this is an excellent way for students to think critically while creating something made from natural materials.
2. **Name organisms only after exploration.** Though naming alone is not enough, it is a critical step in layering further information to help encode information in the brain, thereby increasing the chances of its persistence. Naming should be done outside and, as often as possible, with live organisms. When teaching naming, it is not enough to mention the key characteristics of the organism as a means of identification. Connect the organism to place with as much ecological and cultural information as possible (to what other organisms does this one relate, what organisms depend on this one, what relationship do humans have with this organism, etc.). It is for this reason that exploration of the phenomena prior to naming is essential. The student must have the opportunity to connect and provide a base within the brain to add new terminology (Caine and Caine 1991, 1997).
3. **Create a local connection** (Louv 2006; Nabhan and St. Antoine 1993; Nabhan 1995; Sobel 2004). We must provide students of the natural environment the opportunity to interact with their natural environment over time. Isolated experiences are not enough. Students of all ages must have the opportunity to see how their environment changes over time and in response to specific actions. This involves the repeated observation of a local environment over time as well as those activities that support the crucial "patterning" that is a critical part of all learning (Caine and Caine 1994, 1997).

4. **Connect content to culture**. Worldviews frame the philosophical underpinnings of relationships with nature, and actions upon the landscape are reflective of it. Start students learning about the cultures who have impacted an area—both historical and contemporary. Look for evidence of their impact on the landscape through uses of plants and other biota. Find evidence of culture in place names, in material goods in flea markets, grocery stores, and roadside stands. Openly discuss cultural assumptions about practices and beliefs about nature and impacts upon human inclusive nature.

McClatchey et al. (2013) additionally argue for core concepts of awareness, change, integration of knowledge and methods, information flow, exchange and storage, and systems to be included in curricula throughout the K–16 pipeline as appropriate. They additionally provide examples of learning outcomes and assessments that teachers on this path will find useful.

7.2 Case Studies

7.2.1 K–12 Example: Experiential Field School

Despite the evidence that botanical education is notably absent in most of our K–12 classrooms, there is evidence that this need not be so in this example. Teachers and administrators can be educated about the importance of botanical education in our schools, and in turn provide advocacy to bring it back into the curriculum. But this education need not and *should* not take the traditional route where teachers are lectured to and given directives about what to teach when and how to teach it. If teachers are treated like professionals, and given experiences from which they can make their own meaning, they can and will expand their teaching horizons. It is through these experiences that humans learn. This is a fundamental part of the Mind, Brain, and Education movement (Tokuhama-Espinosa 2010). Consider the following example in which mentor teachers became students of botany and EE, through their experiences in a project-based field school environment:

> This past Spring, 25 middle and high school students were welcomed to the campus of a botanical research organization blessedly housed in a brand new LEED platinum building in an urban area of Texas. Students were chosen from local schools with exceptionally high needs. Our goal was to bring in students and expose them to botanical and environmental issues, encouraging teamwork, communication, data analysis, and interpretation—all while in an immersive outdoor setting. These students did not come alone, they brought with them teachers from their school. These teachers were selected from the schools to serve as mentor teachers throughout the field school experience. We expected to see dramatic changes in the students, in fact this was our goal. We did not expect to see dramatic changes in the teachers, but were thrilled when we did.
>
> Throughout the field experiences, each participating teacher grew and changed in his or her own way. Some were more cautious than others about these teaching techniques they were observing and the environments in which they were being taught. At first, they were

concerned that students were not being "given clear instructions" before an activity as opposed to being allowed to simply experience the environment and discover the necessary skills. But as time passed, so did their concerns. In fact, they began to ask questions about the ways in which we were exposing students to natural phenomena. They commented that they wanted to teach more like this but need guidance… from us. They now had a reason to learn, a reason to want to make deeper connections. Their minds were engaged and learning could now take place.

One particular school that had a new vision for what education could look like on their campus and asked, "Why can't we become a center for environmental and botanical education?"… and so a relationship began based on mutual desires to bring students to a greater understanding of their natural world. These teachers now had a reason to want to learn. Through a grassroots effort, the administration eventually approached our institute with a request for us to guide them through the process of becoming an academy for environmental and botanical science. We gratefully accepted the challenge.

We then began a process of collaborative work on the curriculum. The school receives a standard curriculum for the district but we had the opportunity to work within the curriculum to find appropriate places to introduce plant science and outdoor education. In the end, we found that the best way to include botanical science is through student exploration of systems and the places of humans, plants, and other biota within these systems. Through interviews and focus groups with these teachers, we learned it was the quality and types of experiences they had that truly made the difference.

7.2.2 Undergraduate Example: The Cherokee Worldview Garden as a Place for Biocultural Embeddedness

"Sense of Place" has been called various names by differing disciplines and authors such as topophilia, place attachment, community sentiment, setting, and others (Cross 2001). However, it is most often left out of discussions in the science classroom, despite the fact that outdoor lab activities happen in "place." Building this sense of place into curricula can begin to help students recognize that the "place" where they are located has been through myriad temporal and spatial changes layered with culturally bound human interactions.

The Cherokee Worldview Garden was a 10-year project initiated by the first author, involving students, faculty, community members, Cherokee people, and garden staff in an exploration of the meaning of place to another culture. The garden is located in the South Carolina Botanical Garden on the campus of Clemson University, on land that once belonged to Cherokee people.

Frustrated with the lack of accurate and respectful interpretive material about Cherokee culture in the Upstate region of South Carolina, I began a multi-year project focused on connecting students, faculty, and community members to the culture that came before—through the development of a garden. Though most Cherokee people were driven out of this region in the mid- to late 1700s, reminders of their influence in both cultural and natural systems abound. Rather than a primary focus on plants used for a particular purpose, the intent was to demonstrate worldview of Cherokee people within the context of design of the garden. Making worldview explicit in design provides a substrate for understanding that: (1) There is such a thing as worldview and this may be different, culture to culture and person to person; (2) Worldview impacts how we act upon the landscape; (3) Some actions may be more resilient than others; and (4) Worldview is malleable and, therefore, new ways of relating to the environment are possible.

In addition to many other "situated" projects around the garden, small groups of students enrolled in my (Hall) "Creative Inquiry" classes and developed Digital Stories in collaboration with Cherokee people. The classes created these stories to provide interpretive videos that extended the value of the garden to a virtual world. Elders and cultural experts from the tribe agreed to be interviewed by students interested in particular topics such as medicine, weaponry, basketry, and food. After weeks of preparation on uses of technology, techniques (including human subjects training), specific cultural knowledge, and cultural sensitivity, students developed a more detailed topic around the broad topics and identified a person of interest to be interviewed. Students conducted interviews during a couple of weekend sessions with the whole class—each group helping the other along the way. Artifacts were collected to support stories. These included typical plant photos, end products made from plants (blowguns, etc.), and basic habitat photos. Tribal participants were interviewed and filmed.

Perhaps the most meaningful learning for these science students took place during the interview sessions followed by analysis of these interviews. In one case, students interviewed an important tribal elder whose reputation as a spiritual leader was well known. However, this individual challenged their culturally bound notions of power, expertise, spirituality, and even leadership. Despite preparation regarding cultural differences, this individual, so giving of his time and knowledge, provided them an opportunity to understand deeply that other people have different ways of knowing the world.

As students went on to assemble stories based on these experiences, they had to analyze, synthesize, and evaluate their own work and the work of their colleagues. It was difficult for them to pull away from creating a story that was about their own experience to creating a story focused on Cherokee perspectives with deep meaning for others. Though we ultimately chose not to use the videos, the struggle to create them provided much opportunity for growth and students emerged with a greater understanding of the specific knowledge of place that Cherokee people have and how this affects the natural world in which they are embedded.

7.3 Teaching Strategies

7.3.1 Mind/Brain Connections

Both the *Vision and Change in Biology* (Brewer and Smith 2011) and the more recent *Vision and Change in Ethnobiology* (McClatchey et al. 2013) stress the importance of making multiple connections between plants in our environment and our human selves as another integral part of these integrated and complex systems. These documents also stress the importance of authentic, problem-based, experiential education in immersive outdoor settings as best practices in botanical and biological education. Current research in mind/brain education (MBE) strongly supports these pedagogical approaches. The following are aspects of both *Vision* *and Change* documents that are strongly supported by emerging research in MBE and EE:

- **Authentic**: meaningful to the student on an emotional level
- **Problem based**: there is a reason to learn a skill or develop understanding
- **Experiential**: involving multiple senses, emotions, and intelligences
- **Immersive** (outdoors): elicit emotional responses multiple times to avoid fear

7.3.1.1 Authentic

The learning experience must be meaningful to the student on an emotional level. Traditional approaches to botanical science including lecture and rote memorization are not aligned with best practices from EE and MBE techniques. They do not lead to the development of local knowledge of nature. If their experience in the learning environment only involves sitting, listening, and watching the clock tick away the minutes, there is likely no connection made. There is certainly no connection made to the natural environment. The first step, therefore, is to get them out of the schoolroom and into authentic learning environments in which they may contribute—such as in citizen science programs. Additionally, Caine (1997) says that people need to be supported while doing their work and that this will lead to better flexibility in thinking, creative problem solving, and decision making. When students are working authentically in collaborative groups, we must give them every opportunity to experience the success of being supported in their current workspace and their current *place*. These are the kinds of meaningful experiences that may contribute to a "significant life experience" and outcomes associated with pro-environmental behavior in the future (Chawla 1998).

7.3.1.2 Problem Based

Though we are born with inherent thinking and creativity capabilities, a delicate balance between genetics and environment may determine the ability to develop these talents and skills in deep and enriching ways. Problem-based learning may assist us with this, by centering on a specific problem, helping us to find relevancy, build creativity skills, connect with each other and build deeper understanding. This is powerful as we move ahead with education for twenty-first century skills that employers now demand. In light of this realization, the old models of education fall apart. We are natural born learners—we want to solve problems and we want to do it in groups. So what is stopping that process? Why are schoolchildren not learning effectively within the traditional schooling models? They lack collaborative experiences and the emotional support that allows them the freedom to think again, as they did when they were newborns and toddlers—discovering their world of wonder in play-based learning (Caine and Caine 1997). This collaboration is a survival skill—historically and for the twenty-first century—particularly as our environment changes and becomes more challenging for us to live in. These skills must be learned early, not after college graduation. Great teachers know this and place students directly in a position in which they must immediately put their skills to work. In order for this intrinsic motivation to learn to be activated, a shift must occur. This shift means a transition from a teacher-centered to a truly learner-centered environment.

This immediate use of skills has a historical connection to Dewey for what began as the progressive education movement of the 1930s. John Dewey (1938) called for a "cultivation of individuality" as well as an acquisition of skills that could be put to use immediately, providing for meaningful experience relevant to the learner. Dewey also was a proponent of the learner being directly involved in their ever-changing (and now global) society in a way that allowed them to experience present life as opposed to some abstract remote future.

7.3.1.3 Experiential

There is strong evidence that the amygdala provides for a primacy of emotions over logic in learning environments (Bixler and Floyd 1997; Caine and Caine 1991, 1994; Damasio 1994, 2005; Jensen 2008). Things like thought and emotion cannot be separated; in fact, they *are not* separated in our brains (Caine and Caine 1991). Therefore, all aspects of a person must be considered. This notion was popularized by Gardner (1983) in his landmark book, *Multiple Intelligences*. "Good learning engages feelings rather than viewing them as add-ons, they are a form of learning" (Caine and Caine 1997); thus, we know emotions are critical to learning. In fact, emotions cannot be separated from the experiences that produce them. It is through experience that the brain learns and these are inherent ties to emotion (Tokuhama-Espinosa 2010).

Professor Damasio (1994, 2005), a neurologist and author of *Descartes' Error: Emotion, Reason, and the Human Brain*, describes a "mid-ground" of emotions as ideal in a learning situation. Coupled with our knowledge that emotions and thought are deeply interconnected (Pert 1997), these emotional experiences help us to tap into that "relaxed-alert" phase (Caine and Caine 1997) that our brains are seeking in order to allow us that direct access to higher-order thinking throughout the complex routes of our coveted cortex. Eric Jensen, a student of and a champion for the application of neuroscience research in mind/brain learning techniques, encourages us to consider that "Without context and emotions, information is considered meaningless to the brain" (Jensen 2008).

According to Daniel Schacter of Harvard University (1996), stress hormones tag events in our brains, making them emotionally important and possibly creating a negative-feedback loop. When we encounter stress it actually prevents us from using our higher-order, creative thinking skills and triggers a feeling of helplessness and fatigue (Caine and Caine 1997). In this situation, you can memorize isolated facts but cannot access higher-order thinking to synthesize and generate. However, in some instances, accessing higher-order functions can happen even if there is stress—*if* real *choice* is involved. In fact, under stress, this is the only pathway to the coveted "relaxed-alertness" (Caine and Caine 1997) that the brain requires to perform those higher-order skills.

In a fear-free environment, the fight-or-flight response of the amygdala is not engaged and, thus, free access to higher-order thinking can be more readily achieved. But if we avoid stress and, therefore, avoid the pathway to the amygdala, we can head straight for the promised land of higher-order functions located throughout the cortex. These findings are significant for creating safe, supportive, and fear-free environments—essentially pathways to cortex access.

7.3.1.4 Immersive (Outdoors)

In addition to the lack of outdoor experiences discussed elsewhere in this work (Nabhan and Antoine 1993; Nabhan 1995), emerging brain science constantly points to the importance of experiences out of doors (Caine and Caine 1991), particularly in our own local environments (Sobel 2005). Additionally, these outdoor experiences should involve as much play as possible for children (Caine and Caine 1991; Vadala et al. 2007). In best-case scenarios, immersive experiences must generate emotional responses but without causing fear. This may be more challenging in populations such as urban youth who are disconnected from the landscape. In these instances, students may have a higher-fear expectancy, disgust sensitivity, and stronger desire for modern comforts (Bixler 1997). The goal is to achieve the coveted relaxed-alert phase as described above. However, if the focus is to be botanical science, it is imperative that students have the opportunity to learn about plants where they reside—the outdoors.

One of the hallmarks of MBE is that the brain learns by connecting new knowledge to old knowledge (Tokuhama-Espinosa 2010). Students of all ages must, therefore, have the opportunity to observe plants in their natural environments multiple times, and *over* time. By observing a place over time, students can create an emotional connection (Sobel 2004) that will help them create brain connections (Caine et al. 2008) for learning about plants in their environment.

7.3.2 The Importance of a Philosophical Framework

EE research that makes explicit the philosophical frameworks that guided the design of the original research is needed (Rickinson 2001). In part, this is because of disparate disciplines that have contributed to the literature, but also because there are not clear delineations of the intersections of EE, ecological education, botanical knowledge, knowledge of nature, and so on. In general, the bulk of research on outdoor education literature is more often focused on emotional learning and connection to nature. Therefore, further work is needed in this area to determine what the knowledge-based outcomes are (Nicol 2003). Conversely, research on EE is often more focused on learning outcomes related to changing personal and social behaviors. If evidence demonstrates (as we believe), that learning about nature includes the cognitive, affective, psychomotor, and interpersonal domains, then perhaps the hybrid approach that we have recommended will connect students more deeply to their environments, though this is untested as of this writing.

We recommend that institutions responsible for environmental and botanical education identify a firm philosophical foundation upon which to measure their own message to the community. In our case, this includes a belief in the empirical data from the emerging field of neuro-education, as well as those methodologies supported by both *Vision and Change* (Brewer and Smith 2009; McClatchey et al. 2013) documents. The most salient aspects of these documents are strongly supported by research into brain science. Our philosophical framework is clear and constantly at the forefront of the educational content and pedagogy questions we have to answer daily. Our philosophies may be dated back to the progressive education movement sparked by John Dewey in 1938, though, of course, not all of Dewey's recommendations are followed. Regarding modern thought and empirical evidence, we point to the emerging disciplines of MBE and neuro-education, which is an exciting combination of multiple disciplines with one goal: improving education. MBE has been popularized by Eric Jensen (2008) and Gardner's (1983) *Multiple Intelligences*, and both provide excellent practitioner strategies for classroom and out of classroom implementation.

George W. Bush declared the 1990s as the decade of the brain (Jones and Mendell 1999) with the hope that this would usher in changes in systems (including education). However, over a decade later, experiential education still lies on the fringes, perhaps too closely connected to the original progressive education movements, rather than standing as its own unique learning theory. Though some progressives, including Dewey (1938), may have overreached, suggestions that education must directly connect to the learner's world is still supported by brain research today. This fundamental need to be immersed in an environment for optimal learning has not changed in theory since Dewey published *Experience and Education* in 1938. Now, the emerging fields of MBE and neuro-education may finally be the new platform upon which real change may be launched. Researchers from diverse fields such as neuroscience, biology, and psychology now have the opportunity to fast-track research to the practice pipeline by involving the educational community in current conversations and the search for understanding of how the brain learns and the learner's experience during the process.

7.3.3 Interdisciplinarity

Just as with culture, academic disciplines operate on mental models of their area and thus, practitioners of the discipline "understand the world in terms of the cognitive models they possess" (Davies et al. 2007). To be sure, throughout the careers of both authors, this has been true. However, what we mean to inspire through the inclusion of disparate disciplines in the context of science classrooms is: (1) using interdisciplinary tools to understand, investigate, document, and reflect on problems; (2) using supportive information from different disciplines to provide relevance and meaning; and (3) helping students hone higher-order thinking skills by making the cognitive model explicit. In particular, these may well help students learn about nature in a similar way that holders of TEK do, by providing contextual information layered on local knowledge, management techniques, social institutions, and, ultimately, their own worldview or mental model. In other words, embedding interdisciplinary knowledge and ways of knowing provides a scaffold for local knowledge of nature that may help provide relevance, meaning, and, therefore, become more easily embedded in the brain.

These inspirations also support the whole brain perspective, inasmuch as interdisciplinarity offers students a greater opportunity to connect wholes and parts (Caine et al. 2008) in meaningful ways. Teachers of young children have known this for a long time, linking art projects with the layering of new knowledge and ideas. A group in Connecticut created an explicit project about sustainability integrating science and art. They engaged university students, academics, and community members in a cycle of community engagements that led all toward a deeper and broader understanding of the impact of humans on the landscape (Clark and Button 2011).

7.3.4 Emerging Studies

The emerging field of neuro-education allows us opportunities like never before. Researchers at the Center for NeuroBiology of Learning at the University of California, Irvine and the Johns Hopkins University School of Education (Carew and Magsamen 2010) describe neuro-education as a “nascent discipline that seeks to blend the collective fields of neuroscience, psychology, cognitive science, and education” and which is “opening critical new dialogue between teachers, administrators, parents, and brain scientists.” This new field brings together researchers and practitioners to share wisdom and challenge paradigms (Fischer et al. 2007; Goswami 2006). Additionally, these new findings lend dramatic support to educational philosophers (Dewey 1938; Piaget 1952; Vygotsky 1978) upon whom many of our modern best practices are based.

Experiential education is integrally connected to any educational pedagogy that requires immersion experience in a particular environment, as MBE does. Understanding and naming of plants requires a situational context of place. Experiential education seeks to provide these innovative, meaningful, student-centered, emotionally connected significant experiences for learners of all ages. The literature about SLE is robust and, although not without controversy, experts in the field have long been looking to SLE research to show that critical experiential events play a role in developing adults with environmental (including botanical) awareness (Chawla 1998, 2001; Dillon et al. 1999; Gough 1999b; Payne 1999; Tanner 1980). Some of the controversy surrounding SLE research concerns differences in ages of participants. Chawla (2001) says that she "enthusiastically supports Annette Gough's argument (1999a) that we need to understand the environmental experiences that young people themselves consider significant." But she differs in that she believes we should not restrict our observations to children, but people of all ages. This is necessary if we are to help learners of all ages understand the value of plants in their lives and their critical place in the environmental systems in which they live. SLE research suggests that students who have these significant experiences—particularly outdoors—tend to have pro-environmental awareness. In fact, it appears that outdoor experiences may be far more vital than cognitive outcomes alone—upon which most programs are currently evaluated (Cachelin et al. 2009). There is a need to examine the SLE research as it applies to the significant life experiences of students in our programs.

7.4 Conclusion

7.4.1 K–12 Example: Experiential Field School

One of the key elements to the experience of the teachers in the example described here (Sect. 7.2.1) is that they were being exposed to areas of their city they had never seen before. This became an important part of the experiment. Many of the local places the teachers traveled to with the students were "right in their own backyard" and yet they were unaware of their existence. The goal of these experiences is to encourage teachers to utilize these areas that are in their place. As demonstrated by the research discussed above, it is only through these immersive experiences that learners (of any age) can connect to local knowledge of nature and ultimately engage in more pro-environmental behavior. MBE again provides dramatic support for this initiative. We continue to document the positive influences of outdoor education through disciplines such as cognitive psychology (Berman et al. 2008) and EE research (Rickinson 2001).

In the example provided, teachers came to their new knowledge through their own path. They found a need for more knowledge and deeper understanding and then sought after that knowledge because of this need. As teachers and students came to know the place through study—naming of organisms, the management regimes that brought about the system under study—they began to question prevailing norms that influence the landscape. This is an example of nested nonlinear domains of knowledge about nature that require critical thinking, reflection, and adaptability. Therefore, though teachers were learning about "science," they were doing so in a manner more aligned to the way that TEK holders construct, reflect on, and adapt their knowledge as new information is acquired.

As McClatchey et al. (2013) have delineated, the Experiential Field School actively demonstrated the core concepts of: (1) change (in environments, from one location to another); (2) integration of knowledge and methods (by teaching methodology in the field and teaching structure/function of organisms); (3) information flow, exchange, and storage (through connections up and down the web of life); and (4) systems (by connecting living systems with abiotic parameters).

7.4.2 Undergraduate Example: The Cherokee Worldview Garden as a Place for Biocultural Embeddedness

In order for students, faculty, and community members to understand “place” from alternate perspectives, new information about the influence of other cultures onto already familiar landscapes had to be acquired. In addition to direct experience with tribal members, I regularly employed metaphor and other forms of analogy, including storytelling to achieve this. This is also in keeping with how TEK is conveyed (Berkes 1999).

In support of McClatchey et al. (2013), the Cherokee Worldview Garden (see Sect. 7.2.2) actively demonstrated the core concepts of: (1) awareness (recognizing differences in cultures, practices, and more); (2) change (diversity of organisms by habitat and forest practices); (3) integration of knowledge and methods (teaching skills and methods in context); (4) information flow, exchange, and storage (through connections with nested natural and human systems); and (5) systems (by active discussion of interactions).

7.4.3 Final Remarks

As we move forward in teaching science and specifically local knowledge of nature and botanical knowledge, new mental models of nature are needed (Bang et al. 2007). Since culture impacts cognition, behavior, and social relations relative to habitat (Atran et al. 2004), and because our mobile, technologically oriented society has a severely reduced common-sense understanding of the living world, we may not be able to respond in a responsible manner to changes in ecology without these new models. However, local knowledge of nature is declining; at the same time, a moral consensus to improve the environment or at least avoid doing damage is emerging. This chapter argues that our ability to reverse this trend and live sustainably is ultimately directly tied to more time in nature, more direct experience with nature, and a more in-depth nested nonlinear process of knowledge acquisition and growth, similar to TEK holders of the past and present. In this way, we may become more adaptable and thus reduce our long-term effects on nature.

Additionally, using brain-based, interdisciplinary techniques can help us achieve a greater connectivity to local environments. This is supported by information in the (1) *Next Generation Science Standards K–12* (NGSS) by the National Research Council, the National Science Teachers Association, the American Association for the Advancement of Science (AAAS); (2) *Vision and Change in Undergraduate Biological Education* by AAAS and the National Science Foundation; (3) *Vision* *and Change for Undergraduate Ethnobiology Education in the USA,* informed by the development of number 2; and (4) *How People Learn* by the National Research Council (Brown and Cocking 2000), documents written largely to increase the number and quality of students within STEM disciplines. However, environmental literacy is not just about increasing the number and quality of students within STEM. It is about our survival as a species and, thus, important to us all.

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Part III
Connecting Students to Plants

Chapter 8
"What's That Called?" Folk Taxonomy and Connecting Students to the Human-Nature Interface

Nanci J. Ross

8.1 Taxonomy: Organizing Nature

"What's that called?" is a very basic question asked endlessly by children. Naming or categorizing reveals a common human need: to organize the world around us into recognizable units (Dougherty 1979; Lopez et al. 1997). Berlin et al. (1973) revealed that people go beyond just naming by grouping species together based on common characters, organizing our environment into hierarchical categories. A study working with both science and nonscience major undergraduates found that when presented with unknown and unidentified organisms, the students developed binomial names that often aided in creating these higher classifications (Lau et al. 2009). Classifying is integral to our understanding of our world.

8.1.1 Historical Perspectives on Classification

It is no surprise, then, that classification is fundamental to the scientific study of the natural world. The first systematic attempt to classify the botanical world was by Theophrastus (c. 371–287 B.C.), a student of Aristotle. He classified plants using their morphology, life histories, and by their practical uses such as food, medicine, or fibers. The moniker "father of taxonomy," however, was given to the German botanist Carl von Linné, better known as Carolus Linnaeus, for his publication of *Systema Natura* in 1758. It was here that Linnaeus established the formal use of binomial nomenclature, i.e., two-word species names (genus and specific epithet). Perhaps more importantly, the Linnaean system standardized the use of an inclusive hierarchy such that each taxon was nested within a higher taxon and every species was expected to belong to a group, even if that group was, as of yet, unknown. The huge influx of new species encountered by the explosion of European exploration

N. J. Ross (✉)
Department of Biology, Drake University, 2507 University,
Des Moines, IA 50311, USA
e-mail: Nanci.ross@drake.edu

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of Africa, the Far East, and the recently "discovered" New World necessitated a classification system that could unite this new diversity with the known biota of the time as well as keep such diversity conceptually manageable (Atran et al. 1997). Like Theophrastus, Linnaeus grouped species using common morphological characters, mainly number of floral parts.

Nearly 100 years before Darwin, the classification system Linnaeus created was based on the belief that species were immutable. While practical, artificial classification systems, such as the one used by Linnaeus, are not designed to reveal historical relationships between taxa. After the publication of Darwin's *Origin of Species* (1859), scientists quickly began to adapt the Linnaean system to place the known diversity of life into the new framework of evolution. The first "natural" classification reflecting evolutionary relationships was published by Haeckel in 1868. Despite this new perspective, the hierarchical structure of the Linnaean system was preserved.

8.1.2 Implications for Conservation

Since Linnaeus, science has discovered and classified nearly 250,000 plant species (Mora et al. 2011). From rainforests to deserts, plants form the backbone of nearly every terrestrial ecosystem. These ecosystems provide "ecosystem services" from food, water, and breathable air, to culturally important species like the bald eagle or breathtaking vistas like the view from the south rim of the Grand Canyon at sunset. Yet, to conserve and protect ecosystems requires a clear understanding of what species are found there. Species identification is central to building a conservation ethic (Callmander et al. 2005; Cooper 2008; O'Brien 2010). Estimates of the total diversity on earth suggest there are still 100,000–200,000 more vascular plant species yet to discover (Callmander et al. 2005). In 2002, the Convention on Biological Diversity (CBD) adopted the Global Strategy for Plant Conservation with its first target of "understanding and documenting plant diversity" (Callmander et al. 2005). To do so requires educating and inspiring new generations of plant taxonomists. Not only that, it requires growing an appreciation of taxonomic research in the general public. In this era of looming biodiversity crises and growing rates of species extinctions, a public understanding of the importance of taxonomy is essential for both scientists and nonscientists alike. Unfortunately, studies have found that botanical knowledge and appreciation of plant taxonomy, especially among students, is dwindling (Cooper 2008; Łuczaj 2009; O'Brien 2010; Wolff et al. 1999).

8.2 Making Connections with Taxonomy

8.2.1 Losing Touch with the Natural World

What happened? Historically, survival depended on quickly interpreting and understanding the natural world, making taxonomic knowledge essential. As we moved away from directly interacting with nature, the natural world became more abstract. I once asked a class of mixed majors’ incoming freshmen to define “natural.” Overwhelmingly, they defined “natural” as something far away and removed from human culture or influence. Similarly, modern ethnobotanical studies of traditional societies reveal that as those societies lose contact with nature and become more urbanized, specific taxonomic knowledge decreases (Harrison 2007; Wolff et al. 1999). Coming from a highly developed and urbanized culture, American students lack a framework for understanding how to approach the dizzying diversity of species found in just their local environment, let alone in the world. Each scientific name is seen as a disconnected data point to be memorized and regurgitated for the exam. Even when students learn the characters to identify plant families or genera, for example, those students often consider this new skill as little more than “book” knowledge with little to no connection to their lives. Students often do not realize that they actually use taxonomy every day: a cultural folk taxonomy.

8.2.2 Reconnecting Through Folk Taxonomy

Folk taxonomy is how cultures name, identify, and classify living organisms (Berlin 1973). Despite developing outside the realm of science, folk taxonomies are highly systematic and detailed. Generally, however, folk taxonomies are also highly localized and reflect the needs of the particular culture (Harrison 2007). The folk taxonomy of the Tzeltal Maya of Mexico, for example, labels both local conifer species “pine,” yet identified five different subspecific varieties of their most important food plant: corn (*Zea mays*) (Berlin et al. 1973). During harvest season in modern day Iowa, where cornfields cover nearly 14 million acres (www.nass.usda.gov/ia), corn varieties such as Endeavor, Super Sweet Jubilee, and Peaches-and-Cream are locally familiar names. Different traditions and ways of life are reflected in the terms used to describe and differentiate organisms encountered in the local environment, yet the structure of the folk taxonomy is largely consistent across cultures (Berlin et al. 1973; Savo et al. 2011).

The hierarchical structure of scientific taxonomy formalized by Linnaeus—kingdom, phylum, class, order, family, genus, species—was, in fact, based on the fundamental organizing principles of folk taxonomy. Folk taxonomic systems generally have five hierarchical categories: unique beginner, life form, generic, specific, and (less commonly) varietal (Berlin 1973). Most of these categories are logically similar to ranks in the Linnaean system. The “unique beginner” relates to the broadest category, kingdom. An example of a unique beginner is “plant” or “animal,” yet it can be even broader to mean “living things.” The “life form” category (e.g., “tree,” “vine,” “herb,” “fish”) reflects the practical nature of folk taxonomies by using morphology and ecological characters to group species that seem to represent functional types. This category is often the broadest named category and is made of few (~5–10) groups. By far, the largest category of all folk taxonomies is the “generic” (e.g., “oak,” “maple”) with “specific” and “varietal” (“white oak” or “spotted white oak,” respectively) being reserved for unique, common, or culturally salient species.

The goal of modern scientific taxonomy is to objectively classify every species by its evolutionary relationships. The arbitrary rankings of folk taxonomy seem to run counter to this goal which has led some molecular phylogeneticists to suggest eliminating Linnaean rankings entirely (e.g., Cantino et al. 1999). However, the dominance of generic taxa in all studied folk taxonomies suggests that these classifications may be more than just arbitrary: They may in fact represent human perception of natural, i.e., evolutionary, groupings in nature. In a study comparing the folk taxonomies of Michigan college students with indigenous Maya living in the Petén, Guatemala, Atran et al. (1997) found that despite the difference in overall botanical knowledge (Maya informants had a much greater familiarity with local species), generics were the taxonomic level most recognizable to both sets of interviewees. Similar results were found in a comparative study of undergraduate botany classes from Italy and Hawaii (Savo et al. 2011), confirming that this concept extends across cultures and languages. The authors from both studies suggest that generic taxa represent natural breaks or discontinuities in nature that we have evolved to recognize. This idea is supported by studies showing that folk generics often correspond to scientific genera (Atran 1999; Berlin et al. 1973). For example, the folk generic "oak" corresponds directly to the scientific genus *Quercus*. Since generics are the largest category in folk taxonomies, there is often significant correlation between folk taxonomies and scientific taxonomy, giving students a natural structure from which to begin building an understanding of biological diversity. In the project described in this chapter, students utilize the hierarchical structure of folk taxonomies outlined by Berlin et al. (1973) to design and conduct an experiment to analyze the structure and significance of the folk taxonomy shared by the student bodies at their respective institutions.

8.3 Case Study: Application of Folk Taxonomy in Teaching

8.3.1 Learning Objectives and Instructional Methods

The learning objectives and instructional methods for this exercise are outlined below.

8.3.1.1 Learning Objectives

In the course of this project students will

- be able to describe similarities and differences in natural and folk taxonomic systems;
- gain experience in hypothesis development and experimental design;

- be able to identify critical experimental factors including sample size, potential confounding variables, and data management;
- work collaboratively to collect data;
- critically analyze test results in light of the hypothesis;
- gain practice organizing and presenting data in a formal scientific paper;
- become aware of the cultural significance of taxonomy; and
- recognize the role of taxonomy in their lives.

8.3.1.2 Instructional Methods

The project can be conducted on any campus and adapted for both lecture-based and lab-based course. The teaching methods utilized in this project are geared toward active-learning, hands-on approaches that engage students in authentic, inquiry-driven research. These methods have been clearly established in the pedagogical literature (e.g., Marbach-Ad et al. 2010; Gardner and Belland 2012; Bednarski et al. 2005; Dymond et al. 2009; Roth 1995). The main strength of the project is that it takes students through the entire process of scientific discovery while also allowing them space for personal reflection on the role of taxonomy in their lives. Such inquiry-based learning approaches are key for developing “biological literacy,” the ability to not only comprehend important biological concepts, but to also apply scientific inquiry to address problems and be able to communicate discoveries effectively (Bruner 1961; O’Donnell et al. 1997; Ebert-May et al. 1997).

Throughout the project, from hypothesis development to presentation of results, students will work in teams of four. This is especially important in the early stages of literature review and hypothesis development as well as in interpretation of results. Team-based approaches enhance students’ confidence and allow them to take ownership of both the project and, through that, their learning (Michaelsen et al. 2004; Michaelsen et al. 2002; Treisman 1992). Under the guidance of the instructor, teams provide for the diversity of ideas and perspectives essential for students to work through the iterative steps needed to create a well-crafted experiment. Finally, collaboration is an equally important skill for anyone from scientists to lawyers, architects, or graphic designers.

The project components are:

- Establishing a conceptual background
- Hypothesis development
- Experimental design and data collection
- Data analysis
- Presentation of results

All of the project components (discussed below) are designed to result in an end product of a team-written scientific paper complete with data analyses and references. One of the best aspects of this project, however, is its modularity. Depending on the skills an instructor wishes to teach or the time available, various parts of the method can be added, enhanced, or removed without losing the main goal.

8.3.2 Establishing a Conceptual Background

Teaching students to critically read and interpret primary literature is notoriously difficult (Janick-Buckner 1997). It is also arguably one of the best ways to let students discover science as an ongoing process. They can see concrete examples of hypothesis development and experimental design. Primary literature teaches students how the ideas and facts they learn from science textbooks are actually discovered (Hoskins et al. 2007; Kozeracki et al. 2006). Student's preparation for this project begins with an introduction to the concepts of biological and folk taxonomies through reading and discussing primary literature. Berlin et al.'s (1973) paper details the general structure of folk taxonomies using data from seven different cultural groups and is used as the foundation for the project described in this chapter. Within folk taxonomy literature, this paper is a "classic" since the authors were pioneers in cross-cultural comparisons of folk taxonomic structures (Atran et al. 1997). In addition, Berlin and colleagues provide extensive and compelling empirical evidence and analysis.

At the outset of the project, instructors will provide the foundation paper (i.e., Berlin et al. 1973) to the students to read as homework and discuss in class. Exercises on finding the authors' hypotheses, describing the methods, and writing out the conclusions in their own words will make sure that students really understand the paper. Alternatively, case study approaches to reading scientific literature (e.g., Herreid 1994) are available (National Center for Case Study Teaching in Science, http://sciencecases.lib.buffalo.edu/cs/). These can readily be adapted for the foundation paper.

Since the publication of the Berlin et al. paper, the study of folk taxonomy has continued to advance, providing a wealth of literature for instructors and students to further improve their conceptual understanding. Another excellent reference is Berlin (1973) where the author clearly outlines the basic structure of folk taxonomies as they relate to biological taxonomy. Instructors may wish to also use literature directly relating to the folk taxonomy of a local culture (e.g., Kenny and Parker 2004; investigation of Ojibway folk taxonomy in Ontario, Canada) for teaching the structure of folk taxonomies. Eventually, students will be required to build a bibliography of three to five relevant articles for the final paper. An often overlooked skill in science classes is learning how to locate peer-reviewed scientific papers for use as references. Depending on the available time and the experience level of the students, groups can be assigned to locate additional papers on their own using Web of Science, Google Scholar, or other searchable academic database. With introductory and nonmajors classes, in particular, instructors may choose to provide the students with a small set of preselected articles (2–3) that all groups will use for their background reading and hypothesis development. For this project, the goal is for students to investigate the folk taxonomy of their peers, other university students. Reading and discussion of the foundation paper will provide students with an understanding of folk taxonomy; however, all the cultures discussed by Berlin et al. are indigenous cultures in far-flung places. Will the structure of folk taxonomy persist in the urbanized culture of American college students? Instructors need to take care to ensure that the references selected help guide students toward an investigation of this question. A short list of potential references is: Atran et al. (1997), Begossi et al. (2008), Ferreira et al. (2009), Harrison (2007), Holman (2002), O’Brien (2010), Wagner (2008), Zarger and Stepp (2004). A quick search of Google Scholar will provide many more.

8.3.3 Hypothesis Development

A recent review of rubrics used by science educators (Timmerman et al. 2011) described an acceptable hypothesis as asking a clear, solvable question that is based on an accurate understanding of the underlying concept. One might assume that the most difficult part of that is gaining an understanding of the base concept, yet students often find it every bit as challenging to clearly state a testable question. Initial attempts are often vague and overly broad. For example, “The folk taxonomy of university students is mostly made of generics.” What does “mostly” mean? Is that a testable question? Even a slightly more defined answer is still a bit too vague: “There will be more generic taxa than specific taxa.” What does “more” mean, exactly? If you have 100 plant names, are 51 generics versus 49 specifics really significant? Working in their preassigned groups, have the students work on writing out their hypotheses. Instructors will move through the classroom, listening to the discussions and providing suggestions on narrowing the question to eliminate as many confounding variables as possible. A clearly stated hypothesis is essential for a well-written paper, so instructors should allow sufficient time for each group to compose a solid research question.

The broad scope of the foundation paper, describing the structure and nuances of multiple folk taxonomic systems, could be used as the sole reference for hypothesis development in this project. It would not, however, give students a full appreciation of the process of science. In science, what we work to produce are ideas. These ideas are shared with the scientific community in peer-reviewed publications. New hypotheses and projects often begin with reading something in an article that inspires a new question. This question is then further developed into a hypothesis through broad review and synthesis of the published literature. Unfortunately, undergraduates often lack the familiarity and ease with reading literature needed to synthesize ideas from multiple sources. One method that seems to work well is to have students write out three concepts or ideas from each paper. Then, have them detail how each concept directly relates to the development of their group’s hypothesis for the experiment.

Depending on the level of the class, students may design their hypotheses to extend beyond simply looking at the entire student body as a whole to looking at the folk taxonomic knowledge of various demographic groups (e.g., comparing men and women or science and nonscience majors). It is a simple, quick addition to the interviews to note demographic data, but be sure to adjust the sample size to account for multiple data sets (see the discussion of sample size in the next section).

8.3.4 Experimental Design and Data Collection

Working in teams, students will interview a subset of their peers about naming and recognition of plants. They will then classify the answers using the folk taxonomic categories unique beginner, life form, generic, specific, and varietal in order to analyze the structure of the cultural taxonomy. Students will conduct the interviews using two methods: free-listing categories and identification of specific species (e.g., Wagner 2008). Prior to data collection, however, it is important to spend some time calibrating how the group applies the concepts of classification for real examples.

An ideal approach would be to introduce this project as part of a course unit teaching plant taxonomy allowing students to directly compare and contrast classification systems. American students are often somewhat familiar with the idea of scientific taxonomy, but many still have trouble consistently applying ranks to even familiar species and genera. Key to the success of this project is making sure that students recognize the structures of both systems as well as how to rank actual names. For example, in what rank would you classify "rose"? The genus *Rosa* contains over 100 species, yet many students might mistakenly list "rose" as a species.

This question of how to define a species is not limited to taxonomic novices like students. Within the taxonomic literature there is an ongoing debate about the reality of species as a natural biological category (Chambers 2012; Begossi et al. 2008). Within the folk taxonomic literature, however, some authors argue for the reality of species based on the close concordance between folk and biological species (Begossi et al. 2008; Berlin 1973, 1992). Berlin (1973, 1992) argues that folk taxonomic taxa are rarely classified solely based on cultural utility, but, instead, reflect "natural discontinuities" between organisms. To return to the example of the rose, despite the large number of species within the genus, few species are native to the same geographic area. Within a given local area, most scientific genera are represented by a single member. After their structure, the most significant component of folk taxonomies is that they are local. Generics are the largest taxonomic group in a folk taxonomy, yet represent the "smallest discontinuities in nature which are easily recognized" within the local area where a culture resides (Berlin 1973, p. 261). Thus, maple, oak, and rose are more accurately labeled as generics than species.

If time allows, spend some time getting the students to consider this concept by practicing the interviewing in class prior to the experimental data collection. Using the "free-listing" interview method that the students will be using for the project (see below), instructors can guide the students through a mini-experiment with themselves as the subjects. Instructors will ask the class to list any five plants they can think of and write them on separate scraps of paper. Once completed, students work in their groups to sort the names into piles based on similarity (pile sort method, Boster 1994). Then, discuss with the students how they decided to categorize various plants with the goal of reaching a consensus among the class.

Once the students have smoothed out their own perceptions of classification, they are ready to begin collecting their data. Of course, the first question that students will ask is "how many people do we need to interview?" Sample size is a very important statistical concept for students to understand. In quantitative statistics, we are taught about sample size. A sufficient sample size is needed to reduce the chance of a sampling error that could lead one to accept a false hypothesis. A small number of data points generally do not represent the distribution of the whole, so the rule of thumb (based on the Central Limit Theorem) states that a sample size of $n \geq 30$ is needed to adequately represent the population.

Interview data, however, is qualitative and sampling error is not really the problem. The goal of this project is for the students to uncover the structure of the folk taxonomy of their peer group, so they need to interview enough peers to reduce the risk that they will fail to discover this structure by failing to talk to enough people to uncover the “common” knowledge. DePaulo (2000) provides a simple, mathematic way to calculate the number of interviewees necessary to capture the “perception” (in this case, the basic folk taxonomic structure used) of >90% of the student body population. Each randomly selected interviewee has a 9 out of 10 chance of being in the 90% majority. So, that means that, for the first two interviews, the probability of missing the 10% minority is $0.9 \times 0.9 = 0.81$ (81%). If you continue adding interviewees, you will find that it takes 30 interviews to reduce the chance of missing the 10% minority to less than 5%!

The students should now be ready to conduct their interviews. As stated above, students will use two methods for interviewing: free-listing categories and species identification. Free listing is an interviewing technique in which each subject is asked to list names for certain categories (Gravlee 1998; Quinlan 2005). In this case, randomly selected interviewees (e.g., students stopped while walking around on campus) are asked to simply name ten plants. At first, many students believe that they are being asked for ten scientific names or highly specific species, but once they are assured that any plant will work, nearly all interviewees can come up with ten plant names. Familiar flower and fruit/vegetable names are common, such as “tomato plant.” After the interviews are completed, each group will collate all free-list answers and assign each name to a given folk taxonomic hierarchical category. Alternatively, the class can collate and work as a unit to classify the names. This will help avert the possibility that different groups classify the same plant differently.

For the species identification portion of the interviews, instructors will have preselected a small group of plants representing three to four hierarchical categories found outside of the class building on campus. The class identifies each plant to species (scientific and common name) as well as to a folk taxonomic category. Armed with this knowledge, students ask the interviewees to provide the most detailed name they can, accepting any answer the subject provides (e.g., plant, tree, oak, white oak). The key is to allow the interviewees to give whatever designation they can without bias. The class can explore answers in terms of both accuracy and specificity—discussing the validity of diversity of correct answers (Wagner 2008). Data exploration can allow for development of *a posteriori* hypotheses (e.g., exotic/native species, species in advertisements, mascots). One word of warning, however: Be sure to stress to students the importance of consistency in interviewing method. A different specimen of the same species in another location may elicit different descriptive names by interviewees. In one instance, a group did not finish the interviews in one afternoon. So, they took photos of the identification specimens and completed the interviews back at their dorm. A photo of a tree, or even a clipping from that tree, does not allow the interviewee as much visual and/or tactile data as the entire specimen and will bias the sampling.

8.3.5 Research Ethics

The interdisciplinary aspects of this project make it an excellent vehicle to help students understand that research is about more than just biology. An understanding of research ethics is important for all students, science majors or not, in order to critically evaluate the intellectual and cultural property rights issues that are becoming a political, economic, and social factor in our increasingly interconnected world. Most universities have an Internal Review Board (IRB) committee on campus that reviews and approves proposals for human subject research. Prior to the class, instructors can submit the project to the IRB committee for approval. Then, they can include a discussion of the role of such a committee with the class as part of the teaching on experimental design and methods. Alternatively, IRB committees generally meet multiple times per semester. Instructors can choose to involve the students in the IRB process directly, working with the class to write the proposal. Once approval is given, the project can be conducted later in the semester. IRB approval is required to incorporate data into a larger dataset for publication. IRB approval is not, however, required for the classroom exercise without publication.

8.3.6 Data Analysis

The *Vision and Change (V&C) in Undergraduate Biology Education* final report (AAAS 2011), an NSF funded project to address the state of current biology education, listed quantitative reasoning as one of the essential core competencies. Despite the qualitative data collection methods, this project has many opportunities for students to discover how to quantitatively analyze and interpret data. A simple method is for students to visually examine the proportional representation of taxonomic categories from both free listing and species identification using pie charts or bar graphs. Ideally, however, the students should be able to more rigorously analyze the frequency and abundance of selected categories (e.g., life-form categories, use categories (food, ornamental, etc.) across both *a priori* and *a posteriori* hypotheses. To do so students may need to be guided through a few concepts and suitable analyses.

Nonparametric statistics do not rely on the data fitting a specific distribution (e.g., a normal or Gaussian distribution). The data for this project is qualitative and based on an ordinal or ranked scale. So, nonparametric analysis is needed. In addition, due to the limit of free-listed names to a certain number (10), the proportion of responses that can belong to each hierarchical category is not free. This limitation requires a "blocked" analysis design to eliminate that issue from the analysis. A good choice is the Freidman test. The Friedman test (Friedman 1939) is the nonparametric equivalent of the repeated measures ANOVA and is used for repeated measures analysis of variance by ranks. It will assess the variance in frequency among and between categories (life form, generic, specific, and varietal) to determine if the differences significantly vary from random. Post hoc tests can then be run to determine which taxon category is foremost in the folk taxonomy. The Friedman test is available on many basic statistical software programs.

While the Friedman test can be used to test whether agreement among the interviewees is significantly greater than chance, a cultural consensus analysis can be conducted to further estimate if the folk taxonomic knowledge expressed by the interviewees is truly representative of the population as a whole. Finally, if demographic data was collected, ordination analysis can be used to explore the difference between demographic groups. A complete description of these statistical tests is not possible here, but they are mentioned to give ideas of how to approach the analysis of the data.

8.3.7 Presentation of Results

In science, we work to produce ideas that are shared in written articles and books. An essential skill for science students is learning how to communicate their research in the form of a scientific paper. Beyond improving their writing skills, a body of research suggests that learning of scientific concepts and ideas is greatly enhanced through students writing about science (Keys 1999). Unfortunately, a major hurdle is instructors finding the time to critically read and assess student writing assignments. Group writing reduces the number of papers to grade, but often makes it difficult to determine if the effort was truly a group project and not the work of one or two of the students in a group. A possible method to ameliorate this issue is the use of peer editing.

Peer editing of student writing can do more than just save time for instructors, it can improve student’s understanding of the material and enhance critical thinking skills (Topping 1998). To implement this technique, divide the student groups of four into pairs. Then, assign one pair to write an outline of the Introduction and the other of the Materials and Methods. The pairs will then switch outlines and edit the original outlines. The editing pair must provide a complete first paragraph plus a full editing of the rest of the review outline, (meaning: correcting errors, adding ideas, asking questions, making suggestions for improvement). The pairs will then switch materials again and each pair will use the suggestions of their group mates to finish writing their original section. Groups will be required to turn in all outlines, edited versions, and drafts with names of each student on their respective items. This practice will be repeated for the Results and Discussion sections.

8.4 Conclusion

An understanding and appreciation of plant science is waning at a time when the need for that understanding is so great. Teaching in a primarily undergraduate institution, I have seen that plant science courses are often chosen by nonscience majors to fulfill their life science requirements leading to a hodgepodge of students in any given plant biology course. The challenge of engaging such a diverse pool of interests is great, but the difference between science and nonscience majors is often no more than an illusion. All students respond and engage in a topic if they can feel that topic connecting to their lives. Science courses and projects that highlight the interrelationship of nature and culture can provide that connection as well as provide important opportunities to introduce students to core biological concepts.

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Chapter 9
Learning from the Land: Incorporating Indigenous Perspectives into the Plant Sciences

Michael Benedict (Mohawk), Kelly Kindscher and Raymond Pierotti

The white man sure ruined this country. It's turned back to wilderness.
James Rust (Miwok elder) quoted in Anderson 2005, p. 3

9.1 Introduction

In the 1940s, a prominent plant evolutionary biologist from the University of California and his students were very excited. Working in Lake County, California, they found a growth form of willow they had never seen before, with long, straight shoots rather than the usual branching pattern (Fig. 9.1). As good evolutionary biologists, they tried to figure out what environmental factors might be responsible for this unique form, so they assessed the soil characteristics, looked at moisture patterns, and the physiognomy of the local landscape. None of these tests revealed anything unusual, and they were becoming frustrated when one day they encountered an elderly Pomo woman who was carefully examining the willows. Not wanting to leave any stone unturned, the biologist asked the woman if she knew anything about these particular plants and their unusual form. The woman replied, "Of course, we have been shaping them this way for centuries. They have to be straight if you are going to make the best baskets" (G. L. Stebbins, personal communication 1985).

R. Pierotti (✉)
Department of Ecology and Evolutionary Biology, University of Kansas,
Sunnyside Ave 5003, Haworth Hall,
Lawrence, KS 66045, USA
e-mail: Pierotti@ku.edu

K. Kindscher
Environmental Studies Program, University of Kansas, Lawrence, KS, USA

M. Benedict (Mohawk)
Forester Plant Ecologist, Akwesasne, NY, USA

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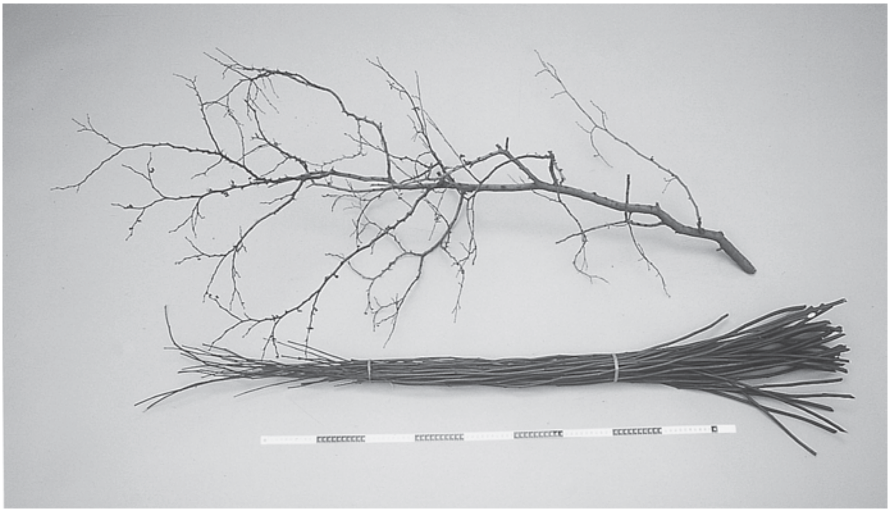

Fig. 9.1 Plant architecture of unmanaged (*top*) and managed redbud (*bottom*) branches. The managed branches are used for basket making and are flexible, long, and straight and lack any lateral branching as can be seen in the unmanaged branch. This is similar to the willow situation described in the text. (Reprinted with permission from Anderson, Kat M., *Tending the Wild: Native American Knowledge and the Management of California's Natural Resources*, © 2005 by the Regents of the University of California. Published by the University of California Press)

This anecdote reveals several important points about Western approaches to the study of ecology and evolutionary biology that probably limit both theory and understanding concerning the functioning of natural processes. First, humans are rarely considered to have been important aspects of evolutionary change before the 1990s and the obvious onset of climate change. Second, the presence and possible role of indigenous peoples as agents of ecological and evolutionary change is typically ignored, except in a possible negative sense, i.e., the repeated emphasis on Pleistocene Overkill as an explanation for the extinction of megafauna (see review in Pierotti 2011a, Chaps. 8 and 9). As an example, Krech (1999a, p. 29) states, "Paul Martin…proclaimed that 'man and man alone was responsible' for the extinctions…. Branding the ancient Indians—the so-called Paleoindians—as superpredators. Martin likened their assault on Pleistocene animals as a blitzkrieg. Evoking the aggressive, assaulting imagery of the Nazi war machine" (For an alternative perspective see Grayson and Meltzer 2002, 2003).

This attitude leads to the third important point, i.e., that the traditional ecological knowledge (TEK) and cultural heritages of indigenous peoples are generally ignored when seeking insights into how animal and plant populations function or when seeking new concepts in community and evolutionary ecology (Pierotti 2011a, b). A major result of this attitude is arrogance concerning how scientists and resource managers deal with indigenous peoples. As one Western scientist has put it: "Imagine people who confidently assume they can best describe and manage the natural resources of an unfamiliar region alone—ignoring local hunters, who know every cave and waterhole and the movements and behavior of a host of local species. Such, historically, has been the custom of most scientists and natural resource managers working in unfamiliar environments" (Johannes 1989, p. 5).

A further issue that arises from such attitudes is the problem of conservation refugees (Dowie 2009). An attitude common within Western ecology and conservation biology is that its practitioners consider systems where humans are present to be "disturbed," rather than "natural." Humans are regularly removed from areas designated as national parks (including Glacier, Yellowstone, and Yosemite National Parks), forest reserves, and wildlife areas, even when these societies have been shown to be a major aspect of ecosystem function (Spence 1999; Dowie 2009).

This issue dates to the very beginnings of the conservation movement. John Muir, founder of the Sierra Club, advocated the view that the California landscape was "pristine wilderness," when in fact he was overlooking the fertile and diverse gathering grounds of California tribes (Anderson 2005). Muir insisted that the Miwok people be removed from the Yosemite Valley, because humans did not belong in wilderness (Dowie 2009, Chap. 1). Western thought persists in defining "wilderness" as ecosystems without humans present (Gomez-Pompa and Kaus 1992). This is not true only in North America. For example, in Namibia, indigenous Juwasi Bushmen were removed from national parks such as Etosha in Namibia, which had a profound impact on the behavior and ecology of lions, *Panthera leo*, that inhabited the park and had established a long-term symbiotic relationship with the human inhabitants, which disappeared when the Juwasi were removed (Marshall-Thomas 1994).

In our experience, the best way to get students to engage topics such as these we have just raised is to engage them in discussion of a reading. For example, the issue of conservation refugees is well introduced in Dowie's (2005) paper in *Orion*. Our preferred format for discussion is to use what we call a "talking circle," in which we have the students sit in a circle with the instructor(s). Marshall Thomas' essay, "The Old Way," from her 1994 book *The Tribe of Tiger*, on Namibia, is also a powerful reading experience for students who enjoy it both for style and content. We begin at one point in the circle and then proceed around the circle, giving each student an opportunity to express their thoughts on the topic. No one can interrupt the student and no one can openly criticize the opinions of another student, although they can express contrary or supportive opinions. This process often reveals surprising levels of knowledge and insight on the part of students, and contributes to overall learning. We will follow up on this theme in later sections.

9.2 Indigenous Perspectives on Biological Processes

There is considerable evidence that the knowledge of indigenous peoples is quite sophisticated and shows considerable insight into how both natural populations and communities function (Pierotti 2011a, b). An example of how the indigenous perspective views the functioning of, and relationships between, organisms and ecosystems, can be seen in the 1911 statement of Okute (Shooter), a Teton Lakota:

> Animals and plants are taught by Wakan Tanka (the Lakota creative force) what they are to do. Wakan Tanka teaches the birds to make nests, yet the nests of all birds are not alike.

> Wakan Tanka gives them merely the outline. Some make better nests than others…. Some animals also take better care of their young than others…. All birds, even those of the same species, are not alike, and it is the same with animals, and with human beings. The reason Wakan Tanka does not make two birds, or animals, or human beings exactly alike is because each is placed here to be an independent individual and to rely upon itself…. From my boyhood I have observed leaves, trees, and grass, and I have never found two alike. They may have a general likeness, but on examination I have found that they differ slightly. It is the same with animals…. It is the same with human beings, there is some place which is best adapted to each…. An animal depends upon the natural conditions around it. If the buffalo were here today, I think they would be very different from the buffalo of the old days because all the natural conditions have changed. They would not find the same food, nor the same surroundings…. We see the same change in our ponies…. It is the same with the Indians…. (McLuhan 1971)

This teaching of Okute is somewhat abbreviated from the original that can be found in T.C. McLuhan's (1971) collection of indigenous rhetoric, where McLuhan identifies Shooter's statement as a description of religious belief. One method we have found to be useful in teaching is to provide each student a copy of the complete text (It can be copied onto a single page) and using the Talking Circle method described above have each student briefly discuss whether this is a spiritual text, a lecture on basic evolutionary ecology, or both combined. For instructors who may be uneasy about how to approach this topic, I provide a brief version of my own thinking of this topic below (A more complete version of my argument can be found in Chap. 4 of Pierotti 2011a).

In his 1859 book *The Origin of Species*, Charles Darwin laid out a set of conditions necessary for natural selection to occur, which would lead to evolutionary change. These included variation among individuals, and also that this variation should have an effect upon the ability of individuals to survive and reproduce. The major theme of Okute's statement demonstrates awareness of variation among individuals: "I have observed leaves, trees, and grass, and I have never found two alike. They may have a general likeness, but on examination I have found that they differ slightly." Okute also states that this variation leads some individuals to reproduce more successfully. Thus, Okute has set up the conditions for the process of natural selection to occur in the context of traditional Lakota knowledge and spiritual teaching, at a time when Darwin's ideas were almost in eclipse in Western science (Pierotti and Wildcat 1997a, 1999b, 2000; Pierotti 2011a, b).

Following the theme expressed by Okute, indigenous peoples around the world have been aware of evolutionary change at the microevolutionary level as a result of their deep understanding of ecological processes. They also understood relatedness among dogs, wolves, and coyotes, which suggests some understanding of macroevolution as well (Pierotti and Wildcat 1997b; Anderson 2005; Pierotti 2011a). This knowledge included tending favored plant species through burning, selective harvesting, and even dispersal of those species that were considered to be important as food items, medicine, or both (Kindscher 1987; Anderson 2005). A major consequence of these activities is that many landscapes and ecosystems were actually shaped through these human interactions, which "created better habitat for game, eliminated brush, minimized the potential for catastrophic fires, and encouraged a diversity of food crops" (Anderson 2005, p. 1).

As indicated above, the irony is that much of what was considered to be "pristine wilderness" was in fact carefully managed landscapes that were appropriate for the harvesting of food and medicine plants, and for wildlife, which preferred the more productive and diverse habitats generated through human activities (Anderson 2005). Even the supposedly pristine Amazonian rain forest was largely impacted by indigenous landscape management (Mann 2005). As a method of exploring this, our first case provides insight into how these sorts of distributions and alterations may have worked.

Our second case provides an example concerning how a supposedly unused plant species, which is even considered to be "worthless" by Western-trained foresters can be both a significant component of ecosystems and have important uses in traditional indigenous cultures. As a teaching exercise, we also provide instructions as to how this species was and continues to be used to manufacture traditional baskets so that instructors and teachers can actually test their skills at applied ethnobiology.

9.2.1 Case Study 1: Ethnobotanical Plant Introductions and Movement of Plant Materials in the Great Plains

The depth of traditional knowledge of Native Americans in the Great Plains can be observed when looking at the sophisticated knowledge that was involved in propagating plant materials. At least some, if not many, native plants were deliberately introduced into new geographical areas by the Native peoples who lived there. There has been some documentation of the movement of plants by Native peoples from one area of the Great Plains to another, especially those species that were regarded as important foods or medicine. For example, Melvin Gilmore (1930) reported that the Pawnee taking a specific wild plum (*Prunus americana*) with them as dried food during their forced relocation in the 1870s from their Nebraska reservation to an Oklahoma reservation, and recognizing that the patches around their new Oklahoma lands were the results of seeds growing that they had planted.

In addition, Gilmore noted a curious distribution of sweet flag or calamus (identified as *Acorus calamus*, but likely the North American native species, *Acorus americanus*) in association with Great Plains village sites:

> Calamus is a plant which very seldom blooms, and I have never known it to produce seed, so that it is not adapted to disseminate itself or invade new territory. But it is found in certain places all the way from Canada to Texas, all these places being at considerable distance from any other stations of this species.
>
> There is a large field of *Acorus calamus* in the low ground in the great bend of the Mouse River in the northern part of North Dakota, not far from the village or Towner in that state. About five hundred miles away to the south on Minichaduza River, near the south boundary of South Dakota, there is another patch of calamus. There are other patches farther to the south in the state of Nebraska on the Calamus River, on the branches of the Loup River, on the Platte and on the Republican River. In Kansas there are patches in places on the Republican, the Kansas, the Arkansas and other rivers. In Oklahoma also there are various patches on certain streams. *Acorus calamus* is a plant very highly valued by Indians for medicinal and other uses. All the places which I have mentioned above as stations of this plant are well known to the people of all the tribes in those regions. And all these stations are in localities formerly much frequented by them. They either are in the vicinity of old village sites, or are located near camping places on old Indian trails. My opinion is that every one of these patches had its original by intentional planting long ago by Indian medicine men. (Gilmore 1913)

Many other species appear to have been cultivated, semi-cultivated, or at least moved about by and with people. The groundnut, *Apios americana*, was prized as food across the prairies, and again has a distribution, with outliers in Cheyenne country of present-day Wyoming that may have been established there by the Cheyenne (Kindscher 1987).

Another example is devil's club (*Oplopanax horridus* (Sm.) Torr. & A. Gray ex. Miq., Araliaceae), which is probably the most important spiritual and medicinal plant to most indigenous peoples who live within its range (Lantz et al. 2004). Different parts of this plant are used by over 38 linguistic groups for over 34 categories of physical ailment, as well as many spiritual applications. Devil's club (syn. *Echinopanax horridus* (Sm.) Decne. & Planch, *Fatsia horrida* (Sm.) Benth. & Hook, *Panax horridum* Sm.; *Riconophyllum horridum* Pall.) is a common deciduous understory shrub occurring in moist, but well-drained, forested ecosystems from coastal Alaska southward to central Oregon and eastward to the southwestern Yukon, the Canadian Rockies, northwestern Alberta, Montana, and Idaho.

Among traditional medicinal uses of devil's club, the most widespread is for treatment of external and internal infections, including tuberculosis. Devil's club has significant antibacterial, antifungal, and antiviral properties (Lantz et al. 2004). It is also used by many cultural groups to treat arthritis, rheumatism, respiratory ailments, and as an emetic and purgative, and can be used as an aid in childbirth (postpartum), for internal hemorrhaging, as an analgesic, to treat stomach and digestive tract ailments, broken bones, fever, dandruff, lice, headaches, and as a treatment for cancer.

Devil's club is a common deciduous understory shrub occurring in moist, but well drained, forested ecosystems from coastal Alaska southward to central Oregon and eastward to the southwestern Yukon, the Canadian Rockies, northwestern Alberta, Montana, and Idaho. Interestingly, there are also several disjunct populations near northern Lake Superior in Michigan and Ontario, which are likely to represent transplantation by indigenous peoples so this valuable species would also be readily available to eastern woodlands peoples.

Although plant movement and relocation are often hard to document, the idea deserves more study, and especially using modern molecular techniques and DNA analysis through which we might be able to compare genetic types from original sources to new geographic locations. All of these examples offer some proof of traditional knowledge and education being used as a way to expand resources for food and medicine.

9.2.1.1 Keepers of the Plants

About 20 years ago, one of us (Pierotti) was participating in an over-dinner discussion with several other university science faculty. As the salad was passed around, one of the professors speared a cherry tomato and asked, "I wonder who the first person was who had the courage to eat a tomato?" referring to the bright red coloration that often indicates an aposematic color in plants, warning possible predators that the object they are considering eating might well be poisonous. Hearing this question and recalling my own upbringing, I was prompted to respond, "Whoever it was, they probably saw a bear eat one first."

Behind my statement was knowledge that in many tribal traditions the bear is recognized as the "plant gatherer," bestower of the secrets and mysteries of plants (Rockwell 1991, p. 6). Among indigenous peoples of the northern American forests, bears are sometimes regarded as creator figures, partly because the highly protective nature of female bears makes them seem exemplary mothers. In these cultures, diets of both humans and bears overlapped extensively. It is virtually certain that these two species often foraged together in the same areas, and that humans entering new habitats learned which plants were edible from close observation of the foraging choices and tactics of the bears. In addition, bears eat certain plants for their medicinal properties. To these nations, bears were seen as almost interchangeable with humans, because they resemble humans, especially after they have been skinned, and bears are known to regularly stand and even walk upright for short distances. The Blackfeet word *o-kits'iks* refers to both the human hand and the paw of a bear (Grinnell 1962). The Ojibwe word for bear is *anijinaabe*, which is virtually identical to their word for themselves, *Anishinaabe* or *Anishinaabeg* (the latter is the preferred spelling of Anishinaabeg author Louise Erdrich). This metaphor is given flesh in Louise Erdrich's novel *Tracks*, where the main character is an Anishinaabeg woman who may or may not be a bear (1988).

In the Hidatsa and the Blackfeet, there is also a tradition that bears taught people how to trap eagles (McClintock 1910; Wilson 1929). Bears are of symbolic and spiritual importance to numerous peoples among indigenous Americans (Rockwell 1991). The Tlingit people of southeastern Alaska refer to grizzly bears as half human and also to be close relatives of the Bear clan of the Tlingit people. At some levels this appears to be more than metaphor. A story is told of a Tlingit elder from the Bear clan who died. As his body was being carried by truck to the village of Angoon, "a half dozen or so bears materialized out of the woods and lined the road from the dock to the village.… As the truck [carrying the body] rolled by, some [bears] actually stood up" (Martin 1999, p. 37). Although to a Western-trained scientist this story may be hard to accept, this story was confirmed to me (Pierotti) by a student at Northwest Indian College, who assured me that the elder involved had been his relative. Such relationships, built on respect built up over long periods of time, are not often part of the Western scientific experience. Even if they were, it is unlikely that they would be published.

9.2.1.2 Using Indigenous Histories of Plant Movements as a Tool for Teaching Lessons in Conservation, Ethnobotany, and Ecosystem Dynamics

Exercise Although the typical classroom experience is limited by the twice-a-week 1 h and 15 min block for the ethnobotany class I (Kindscher) teach, I use the example of indigenous people moving plants as an example in my class to interest the students in a broader range of ideas. To have them realize that the plants around us, and the ecology around us are shaped by history, the history of people and their use of plants, and management of the ecosystem, is a powerful reminder of the impact of humans on this earth, and of our capacity for creating change. I also like to speak of this in positive terms—of the possibilities that we have to enrich and enhance our environment to bring wildness and wild plants into our surroundings, and for the great opportunities that we have to restore and rejuvenate the lands around us with native plants that have uses, and uses for food and medicine that we (indigenous, settlers, inhabitants, or immigrants) can enjoy and benefit from today.

I believe that teaching must transcend the classroom, as it must not only make us think beyond the intellect in the classroom, to thinking about the world around us. But not only thinking about it, but learning about it and experiencing it. Every class I teach has the opportunity to join me in the field, on a field trip to learn about plants and their uses, and the ecological setting in which they are found. For a spring semester course in Kansas, this will happen at the end of semester, as the landscape greens up, and usually as an optional class because it extends beyond both the place and the time frame of the classroom. In these out-of-the-classroom experiences students can truly "learn from the land."

Possible questions related to these topics that can be used to stimulate class discussion include: "Is it better to consider North America in 1492 to be a 'Virgin' or a 'Widowed' land, as described by Charles Mann (2002, 2005)?" Mann's article in Atlantic Monthly (2002) is a good summary of his ideas that almost all of the Americas were profoundly influenced by pre-European peoples and that they managed the land for both their own benefit and that of wildlife. This is a readily readable essay that can be used to promote class discussion, either using Talking Circles or general discussion. In the context of this idea, discuss the relationship between indigenous people distributing plants to areas where they can be used for food or medicine. It may also be useful to consider why Bear was considered to be the "Keeper of the Plants" by numerous tribes. What does this imply about relationships between humans and bears? Is this similar to the relationship described between lions and Bushmen by Elizabeth Marshall Thomas (1994)? Finally, the class can discuss whether or not they consider the "gardening" practices of indigenous Americans to be similar to the gardening practices practiced by people of European or Japanese ancestry?

9.2.2 Case Study 2: Traditional Basketry Using Black Ash

The Legend of the Black Ash Basket. This legend is very old.

> The making of this basket began as the vision of a great Anishnabe leader with a concern for the future of his people. Because the knowledge for the construction of the baskets came in a vision, a gift from the Creator, it is considered sacred to many Anishnabe elders. The Black Ash Basket was the vision of Black Elk, a man who was nearing the end of his time and was concerned for his people. He could see the restlessness in his people, and he wanted to leave them with something that would not only help them provide for their families but also teach them the patience they needed. Black Elk asked the Creator what he could do to help them, and the Creator gave him this vision: "When Black Elk died, the people were supposed to burn his body and then bury the ashes that remained in a special

> place. Out of the ashes would grow a special tree. The people were to watch over this tree and protect it from harm. This was to be considered a very sacred thing. When the tree matured, it was to be cut down, and the growth rings were to be removed." This process was shown to Black Elk in his vision. He saw how to remove the rings by pounding the tree and how to prepare the strips to fashion them into baskets. Black Elk was happy with this vision from the Creator. He gathered his people together and told them what was to be done. He knew his people would now learn patience by waiting for the tree to mature, preparing the growth rings, and then finally by weaving their baskets. This would also give the people a way to help provide for their families, by selling or trading their baskets. (Canadian Aboriginal Products, International 2000)

Black ash (*Fraxinus nigra*) has been an important tree for the manufacture of utilitarian and decorative baskets for many Native American Tribes, probably for thousands of years. After arrival of Europeans, which led to loss of lands and traditional lifestyles, basketry became an important local industry that allowed Native Americans to trade for goods and cash to support their families.

One of us (Benedict) describes his personal experience in trying to recover traditional methods concerning use of Black Ash:

> I learned at an early age some of the more commonly used medicinal plants. After retiring, my grandparents started buying and selling black ash baskets from local basket makers and would sell them to shops scattered throughout the northeast US and Ontario. Although no recent or current family members were weavers, I became interested in learning how to weave, and in my mid-twenties I finally found a teacher through a program sponsored by the Mohawk Nation. Over the course of several months I learned the basics of weaving pack baskets and then eventually laundry baskets.
>
> I wove baskets for several years, then stopped for lack of time while trying to earn a living. It wasn't until the late 1980s that I started to rekindle my interest while I worked for the St. Regis Mohawk Tribal Environmental Division. My brother and I sat on a committee that consisted of both American and Canadian band council employees, called the Akwesasne Environmental Task Force, charged with looking at local environmental issues. Some elders had requested that the Task Force look into reintroducing black ash into stands that had black ash historically on and around the reservation.
>
> After graduating from the University of Kansas, I undertook a Master's of Science in Forestry work at the University of Minnesota. I knew already knew my topic of study would be with black ash. Fortunately, I found committee members who were quite interested in my topic. My goal was to supplement the lack of information on black ash ecology and management and support the work of the Akwesasne Task Force. I chose to study the ecology of black ash to learn what site conditions fostered the best growth for quality basket-making trees. My study relied on Native observations in selecting a tree for harvest. I wanted to quantify using science these observations and techniques that were taught and passed down for hundreds of years.
>
> For much of my graduate work I had to deal with ridicule for studying an unimportant non-commercial tree. During this time I truly realized that few people understood or were interested in culturally important plant management from a Native perspective. All too often the snickers concerned, "how many baskets are you making" and few questions about what I was working on. It was obvious that when it came to a Native trying to break into the field of science, people only want to hear a Buckskin and Feathers Speech and ignore the rest of the work. Not that a Buckskin and Feathers Speech can't be helpful in trying to get your message across, but it more often than not leads to the Noble Savage image.

In some communities, basketry was in danger of becoming lost because of social changes and declining stands of black ash. Often the baskets were sold for literally pennies for the small fancy baskets, and a few dollars for larger utility baskets, which often discouraged younger people from learning this skill (Angus George 1982, personal communication).

In recent years, basketry has undergone a renaissance, along with other Native traditions that were in danger of disappearing. An effort to preserve this important tradition has encouraged native basket makers to market their products as works of art. Underlying the skill required to make a basket, there are centuries-old knowledge concerning the ecology of black ash trees. You cannot simply go into the woods to pick a tree for basket making, because very few trees in a stand are suitable for basket making. A person looking for a good tree must have an intimate knowledge of its ecology and population structure along with patience and respect for this particular species.

Although it is only one of several tree species used for splint basketry, including maple, white ash, oak, cedar, and spruce (Mowat et al. 1992), black ash has unique qualities that make it the most widely used tree for splint basketry in areas where it grows. Its first, most important quality is the relative ease in separating the annual rings from which splints are made. The second is the properties of the wood itself; when soaked in water, a black ash splint can be bent into a right angle without splitting and will keep its shape after it has dried. The third property is the durability of the wood. With heavy use and the repeated wetting and drying that pack baskets and utility baskets are often subjected to, the splints hold up for many years. One author (Benedict) has a small basket given to him by his grandmother over 30 years ago that one time was used as a clothespin basket and was left outdoors for a number of years before it was given to him. Although now discolored and tattered, it is still used to hold basket-making tools.

9.2.2.1 Native American Basket-Making Tribes

The four main groups of Native Americans who historically made, and continue to make, use of black ash are the Haudenosaunee (Iroquois) Confederation in New York State (Mohawk, Oneida, Onondaga, Cayuga, and Seneca), Hochunk in Wisconsin, Anishinaabeg (Ojibwe) in Canada and the North Central United States, and Wabanaki (Maliseet, Micmac, Penobscot and Passamaquoddy) in the state of Maine. Black ash remains an important resource to these tribes both economically and culturally.

Native American development of splint basket making dates back until at least 2000 ybp because an archeological site in the State of Maine revealed remnants of 2000- to 4000-year-old ash splints used as fish weirs on the bank of Lake Sebasticook (Benedict and David 2000). Of equal importance to such archeological discoveries is oral tradition, which provides a record of traditions, guidelines to living, and a history of who these people were and continue to be. Unfortunately, scholars often dismiss the oral tradition as trivial little stories told and retold by "primitive" peoples who are steeped in superstition when they are just as valid as Western written records of history (Pierotti 2011a, b). In the last few decades, however, oral traditions as explained by elders have been found to be the equivalent of written documents in legal proceedings (Glavin 1998).

The main barrier to people of modern Western cultures in trying to understand Native stories is the compartmentalization of physical science, spirituality, and social issues (Pierotti 2011a). Another issue is hearing important stories in English, rather than the original Native language (Marshall 1995). In attempts at fairness to everyone, as often happens with translations, cultural and intended meanings are often lost because Western languages often lack terms for indigenous concepts and use watered down English words that do not convey the true meaning.

We have included two Native stories about black ash in an attempt to show the importance and respect given to this one plant species among many others. The first is the Ojibwe story, which opened this section and tells of how they were given the black ash tree as a gift and the responsibilities that came with this gift. This further illustrates both the spiritual and physical responsibilities required to manage this particular resource, in that its first part reveals understanding of the ecology and management required for this species. Black Elk's ashes may symbolize the use of fire as a management tool for this species, just as it is used today in forest management to control understory competition and assist natural regeneration.

The second part of the story illustrates the patience and care needed to manage this special tree. Modern basket makers say that a tree must be at least 50 years old before it is ready for use and that every tree is not suitable for basket making. The third part of the legend describes how this tree is to be prepared for use before baskets can be made. Throughout the legend, civic, ethical, and spiritual responsibilities are constantly emphasized. The black ash tree was not only a spiritual gift, but a material gift as well, given for the physical and economic needs of the people. A common theme in this and other Native legends are that these are gifts, not rights, and must be treated as such or risk losing them.

The second story comes from the Creation story of the Wabanaki people of Maine and adjacent parts of Canada, involving the Creator's helper Glooscap. In this story the people (Wabanaki) emerged from a black ash tree:

> In the Old time, long before the White Man came…. Glooscap made men: Taking up his great bow; he shot arrows into the trunks of ash trees. Out of the trees stepped men and women. They were a strong and graceful people with light brown skins and shining black hair, and the Creator called them the Wabanaki, which means those who live where the day break (www.indians.org/welker/hispeopl.htm).

This provides another example concerning the historical importance of the black ash tree to these tribes. This story describes an important point in their history "long before the white man," which indicates that black ash was in use long before European contact (see also Marshall 1995). This is an important part of their creation story defining who they are and how they view the world. Historical accuracy of these legends is not diminished by lack of written documents, because these stories were carefully handed down to certain tribal members whose responsibility was to keep their tribal identity alive (Marshall 1995; Glavin 1998; Anderson 2005; Pierotti 2011a).

The importance of this particular tree to these tribes cannot be overstated. Splints from this tree species provide strong, durable, and lightweight material from which to make containers. Pack baskets made from black ash may have contributed in part to the defeat of the British during the American Revolution by keeping George Washington's army at Valley Forge from starvation. The Oneida, who were allied with the Colonials, carried hundreds of pounds of corn in black ash pack baskets while walking on snowshoes (most likely also made from black ash) to feed Washington's army (Oneida Indian Nation Web Site 2001).

9.2.2.2 Selecting a Basket Tree and Preparing the Splints

Through experience, basket makers know that only one or two out of every ten trees will be good enough for basket making. To qualify a tree must be at least 12–13 cm (5–6 inches) in diameter at breast height, have a trunk at least 1.5–2 m (4–6 ft) in length that is straight with no visible knots or defects. It must also have at least 20 years of annual ring growth with a minimum average ring width of 2–4 mm (basket makers use a nickel as a gauge to measure for minimum ring width). Once a tree is selected, the basket maker will cut into the trunk either with an axe, or use an increment borer to check the rings.

The most preferred sites for harvesting black ash are vernal ponds, which flood in the spring and dry out by early summer. If these vernal pond sites cannot be found, then the more typical forest-wetland stands, which are not vernal in nature, are selected. Within these stands, trees that are growing slightly higher than other trees or in the upland-wetland interface are often selected. The reason for this is that experience has taught basket makers that trees growing under slightly drier conditions usually have better growth rates than those in much wetter conditions. It should be noted that drier sites are relative to the average black ash tree growing within a particular stand.

Although considered a wetland species, black ash also grows quite well on mesic sites once it becomes established. It is considered a wetland species because it is one of only a few tree species that are able to grow under wet conditions. On upland sites, it is probably outcompeted by other upland tree species during its seedling stage of life. However, this does not mean that the best trees grow well in extremely dry conditions. The best trees for basket making seem to grow where they can have the best of both worlds: good water availability, but not saturated soil.

Basket makers take care in selecting candidate trees because the only way to check for ring growth is to either cut into the trunk with an axe or use an increment borer. By following these guidelines about optimal site locations, basket makers limit the damage to as few trees as possible. After a tree is selected and cut, the splints are either prepared where the tree was felled or, more frequently, logs are taken home. Stems much less than 2 m (6 ft) in length are avoided because they are harder to work with when preparing splints, because it is preferable to have splints as long as possible to avoid too many splices when weaving. Although trees can be felled at any time during the year, they are usually felled during the winter because of the easier access when the wetlands are frozen (Fig. 9.2a).

Fig. 9.2 Photos of basket making from start to finish. **a** Workers are carrying a log out of the forest. **b** Pounding ash log. Notice how the splints separate into layers. **c** Foreground tool is a gauge, which is used to cut splints into predetermined widths. **d** “A” frame is used to split the splints down to the thickness of paper. **e** Molds are used to start baskets. Notice how the splints are bent into a 90° angle at bottom. **f** Weaver is finishing a corn-washing basket by binding the top rims with 1/8-in wide splints. **g** Finished fancy baskets. Dark bands are sweetgrass woven into a basket. **h** Finished pack baskets and coils of splints

9.2.2.3 Preparing a Black Ash Log

Each log is debarked, just before pounding, with either an axe or drawknife and placed on two pieces of wood that have been notched to keep the log from rolling. To set the width of the splint strips before they are pounded, two parallel incisions (that run with the grain of the wood), 2 inches deep and 3 inches apart, are made with a knife or an axe at the small end of the log. The log is then pounded beginning at the small end toward the large end of the log with either the backside of an axe or a small sledgehammer with overlapping blows until the large end of the log has been reached. Care must be taken not to hit either too lightly and/or too hard, because a too light blow will separate only two or three annual rings and a too hard blow will crush the splints (Fig. 9.2b). A log must be wet before pounding; green logs work best. If a log has dried out it must be soaked in water for a week prior to pounding; otherwise the splints will fragment.

The goal during pounding is to try to get at least eight layers of splints from each strip that is pounded, because the top splint for each strip is always discarded because the pounding damages this layer. When the pounding has reached the large end of the log, the splints are then peeled off from the small end toward the large end.

The reason black ash rings separate relatively easy is that the springwood within the annual ring has much larger and thinner-walled pores, or vessels, which are crushed much more easily than the summerwood, which has smaller and thicker-walled vessels. Cores from a sample of 63 black ash trees on the Chippewa National Forest indicate that a little more than 50 % (mean 55.6 ± 24.7 %) of a typical annual ring is springwood. Therefore, splints are the summerwood fraction of an annual ring and less than half of the annual ring is used. There are other methods for making splints in addition to the one just described, and there are variations of the process describe above. Some basket makers will split and quarter the log. These smaller sections are placed on a hard surface and pounded with a smaller hammer. The end result is a long strip of wood veneer or splint that is ready for preparation for weaving.

Splints from both the sapwood and heartwood are used; sapwood is the most desirable because of the light, almost white color. The heartwood splints are light reddish-brown in color and are used for making utility baskets or dyed to make colorful splints for use in making fancy baskets. The splints are smoothed with a knife if they are less than 1 mm thick to remove the remnants of the springwood, which was shattered during pounding. Splints may also be split one to several times (if they are thicker than 1 mm), down to the thickness of paper, by scoring them halfway through them with a knife, and essentially peeling them apart as if peeling the backing off of contact paper. When split in this manner, the splints look and feel much like ribbon. The splints are then cut into predetermined widths before they are woven into a basket (Fig. 9.2c, d). Splints are quite strong and flexible when wet and can be less than 1 mm thick and 1 mm wide and used to bind the tops of baskets in much the same way as sinew or spruce root is used. Within limits, they can be pulled quite hard before breaking. Black ash splints can also be bent into a right angle without splitting when they are wet, which is important when starting the bottoms of the utility baskets (Fig. 9.2e, f).

When the basket is completed and dried, it will hold its shape for years and withstand repeated soaking and drying over many years before deteriorating. These qualities are why these particular tribes have favored black ash over other species, such as red maple, hickory, white ash, and oak, for splint basket making. For a video on this topic featuring one of the authors, see: http://www.woodculturetour.org/DestinationContentVideo.cfm?spots=145#.UU5fSxnaixV.

9.2.2.4 Types of Baskets

Ash basketry, as with all other types of basketry, started with a single purpose: to hold or carry food and other items of value. The first group is the utility baskets that were used for everyday storage and transporting heavy items. The second group is fancy baskets, and ceremonial baskets, which are used around the home and for ceremonial use (Fig. 9.2g, h).

Utility Baskets

Utility baskets are made in many styles and are used for a variety of jobs. The first and probably best known utility baskets are pack baskets, which come in any number of sizes from the small berry-picking basket to baskets that can carry harvested crops, camping supplies, meat, or fish.

The next type of basket that was, and remains, important to the Haudenosaunee is the corn-hulling basket used as a sifter for processing hominy corn. The process of removing the hulls is called washing corn. The hull is the plastic-like covering on a kernel of corn. To soften the hull, hardwood ash is mixed with water to produce an alkaline solution to which the corn is added and boiled for several hours. The final step is to pour the solution and corn into the basket and rinse several times with fresh water. This rinses the alkaline solution from the corn, and flushes the remaining hulls through the bottom and sides of the basket. This may seem like a waste of time and extra work, but washing improves the taste and enhances the storage quality of the corn once it is dried. The Haudenosaunee used two other sifters: the meal sifter was used for sifting ground corn, and the ash sifter was used for sifting the charcoal out of the wood ashes for use in washing corn (Parker and Handsome 1968).

Fancy and Ceremonial Baskets

Originally, fancy baskets were used for storing household items and later evolved into intricate baskets that were sold to European settlers. Fancy baskets are made using dyed splints and sweetgrass, which are woven with natural-colored splints and porcupine quills and range in size from thimble to platter size. These baskets are also used in different ceremonies among several of the tribes; these can be plain baskets used to hold sacred items or specialized baskets such as the wedding basket used for traditional Haudenosaunee weddings. The only limit to a basket's design and size is the weaver's imagination.

Men typically make the larger utility baskets and women typically make fancy baskets. This preference results primarily because of the extra physical work involved in finishing the larger baskets. Carved rims and handles require a fair amount of strength and involve labor-intensive manual wood-working techniques.

Women, on the other hand, tend to have more manual dexterity to weave and they prefer to work with smaller baskets. This by no means prevents either gender from making both kinds of baskets, and there are some fine examples of men making fancy baskets and women making utility baskets.

9.2.2.5 Current Issues Among Basket-Making Tribes

Basket styles, splint finishing tools, and techniques vary between different families within a tribe and between tribes. The largest numbers of current basket makers are from the tribes in the northeastern USA and eastern Canada. The more prominent Native basket makers are the Maliseet, Micmac, Passamaquoddy, and Penobscot from Maine and the Mohawks from northern New York State.

Tribes from Maine relied heavily on the local fishing industry that bought fish baskets for many years, until the introduction of cheaper plastics and other materials. With this began a decline in the number of basket makers, as well as easily accessible black ash trees, which have become rare due to the previous high demand for basket trees. Other factors contributed to the decline available black ash, such as forestry and logging practices (Trial and Devine 1996).

During the 1960s and early 1970s the Mohawks also saw a decline in the number of basket makers and subsequent decline in locally available black ash trees for many of the same reasons as those observed in Maine. The area in which the Mohawks now live historically did not have a large population of black ash, and those few populations that did exist were depleted because of basket making and land-use practices on and off the reservation. Both the tribes in Maine and New York State had families who depended heavily on basket making for hard currency during the nineteenth and early twentieth centuries due to the lack of jobs on and around the reservations. As the twentieth century progressed, cheap transportation allowed residents to seek higher-paying jobs off of the reservation, resulting in a move away from traditional practices and a proportionate decline in basket making.

However, during the last 30 years the younger generation has once again become interested in learning traditional lifestyles, including ash basket making. This renewed interest has also highlighted the need for locally available black ash trees. Today most of the black ash used by the Mohawks is purchased from other tribes in northern Ontario and Quebec.

In Maine there was a noticeable black ash dieback leading to concern over the future of the species (Trialand Devine 1996). As a result, the tribes from Maine organized to form the Maine Basketmakers Alliance, whose purpose was to preserve the basket-making tradition for future generations. Maine tribes and the Mohawk Nation have begun actively searching for ways to increase the number of basket makers and local supplies of black ash and sweetgrass.

Since 1992, the St. Regis Mohawk tribal environmental department has been collecting black ash seeds and growing them in nurseries for the purpose of reestablishing ash stands on the reservation. This effort in learning how to propagate black ash from seed has been headed by Les Benedict and Richard David under a joint project sponsored by the American and Canadian tribal governments (Benedict and David 2000). A number of different sites have been planted, and former black ash sites on the reservation have been successfully reestablished. Both the Mohawk and Maine tribes have been meeting over the last 10 years to share information.

Using Basket Weaving as a Tool for Teaching

Exercise Discuss the role of baskets in contemporary life. Have any students made baskets or participated in basketmaking? If so, how did they learn to do this? Are there special types of plants they use in basket making and would they rather gather their own materials or buy them at Hobby Lobby? (If possible, you could have the students practice the techniques described above in basketry.)

Baskets were and are used in Native communities either for utilitarian, decorative, or ceremonial use as well as for income. There are stories that some older basket makers could weave baskets that could hold water using black ash; however, this unique skill may be all but forgotten. Tlingit basket makers weave water-tight baskets called cooking baskets using materials from Sitka spruce roots.

While there are many different weaving techniques and materials used by the 500 or so remaining tribes, the focus will be on one material made from the black ash tree. There are many different materials used for basket making among the tribes that use black ash, such as paper birch, willow stems, red osier dogwood, sweet grass, bark from eastern white cedar, cattails, and other pliable materials. There are probably many more plants that were used; remember that these tribes, as well as other cultures, learned to use what was available for survival. It is a common mistake to say that it's "Native" American, as each tribe or group of localized tribes is as different in traditions as are many European countries. The use of black ash as basket material is used by a number of tribes where the black ash tree is "native," from northern Minnesota, Manitoba to the northeastern USA and Canada. There are different styles among the tribes that use black ash that collectors can identify as having been made by Mohawk, Ojibwe, Ho-Chunk, Penobscot, and others.

These tribes and others throughout North and South America cannot go to Hobby Lobby to obtain their material. They must collect the material from the forests, riverbanks, or fields. For those who are learning to weave, commercial materials are available. I have personally tried some of these commercial materials, but they do not have the same unique characteristics that black ash material has.

A number of websites and books show the basic weaving techniques, using what is known as "plaiting" basketry. This involves using the material to weave over and under. What makes black ash so unique is that the same piece of material (splint) can be used to make large utilitarian baskets such as pack baskets, harvesting baskets, or small decorative baskets such as a sewing basket down to a thimble-sized basket.

9.3 Conclusion

The Mohawk Nation is on the cutting edge of black ash regeneration. Crucial to this project is the experience from Traditional Ecological Knowledge gained by the elders of this community over many centuries of using this resource. Without this guidance, the efforts of these tribal scientists would have no doubt been much harder. Traditional Ecological Knowledge combines the physical, spiritual, and social aspects of the natural world, in which humans are considered to be only a small part of that world (see also Anderson 2005; Pierotti 2011a).

In contrast, Western science has sought to separate the physical, spiritual, and social aspects of society into separate disciplines, which has distanced humans from nature. In spite of the differing views, Native scientists realize modern science possesses the tools needed to help solve environmental issues. Showing greater flexibility than the Western tradition, tribal scientists and resource managers do not have a problem combining Western scientific methods and traditional ecological knowledge to better understand the ecology of black ash and other modern issues.

Black ash is recognized not only for basket making, but also as a medicinal plant used for fertility problems in humans and as a spiritual gift to that ties the people to the natural world (Herrick and Snow 1996; Richard David, personal communication 1999). Recent efforts to manage black ash are part of a larger recent trend in forest management to look at species other than those that have historically had a high market acceptance and value. Although black ash is important commercially to these few tribes, many other species of flora and fauna are just as important to the health and diversity of our forests.

We have also discussed how indigenous peoples root their beliefs in the understanding that nature has an inherent ability to renew itself (Anderson 2005). This belief is reflected in annual ceremonies that are often tied to important events in nature. In addition, Native religious practices and ceremonies are derived from traditions linked to hunting and gathering (e.g., First Salmon Ceremonies, Sun Dance (which derives from buffalo hunting), Green Corn Dances) (Pierotti 2011a).

This idea that nature has the capacity for renewal if humans allow this to take place is not limited to indigenous peoples. Such beliefs also appear in European traditions, and even the English language is full of terms whose forgotten meanings point to this concept (Anderson 2005). As examples, *resource* is derived from a French term that means “to rise again,” and *horticulture* means “to care for with respect.” This should show us that even our European ancestors shared concepts with indigenous Native American traditions, and that these attitudes are not unique to tribal peoples, but can be achieved by anyone who wants to put in the time and effort (see Pierotti and Wildcat 2000, and Pierotti 2011a for an extended argument on this point).

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Chapter 10
Pedagogy and Botany of the Columbian Biological Exchange: The 1491 Meal

John Richard Stepp

10.1 Introduction

Beginning with the dawn of humanity in the savannas of Sub-Saharan Africa, people have moved and adapted to new environments. In a remarkably short period of time, *Homo sapiens sapiens* spread across the planet and into virtually every biome. In all instances, the discovery of new plants for food and medicine was crucial for new settlements and survival. It is reasonable to assume that, even before the rise of agriculture, early humans took plants with them on journeys to ensure that they would have access to important resources. However, it is really with the origin of agriculture that human-directed plant migrations increased significantly across long distances and continents. Human history can be written in large part through the movement of useful food, spice, and medicinal plants from their original centers of domestication (Musgrave and Musgrave 2001; Laws 2010). Despite these migrations, both plant and human, the flora of the Old World and New World remained *mostly* separate until large-scale European conquest and colonization began in the 1500's.

The arrival of Europeans into the New World created one of the greatest transformations of human history and culture. The process of conquest and colonization led to the transfer of unprecedented numbers of domesticated plant and animal species both from and to the New World. The historian Alfred Crosby described this process as "The Colombian Biological Exchange" in his seminal work on the topic (Crosby 1973). The second part of the title for Crosby's book was "Biological and Cultural Consequences of 1492," thus noting the importance of that year marking the beginning of *widespread* European arrival in the New World. Within a relatively short period of time from a historical standpoint, entire regions and culture became reliant on new food crops, both staple and otherwise, that they had never known before. A notable example of this phenomenon is the arrival of the potato (*Solanum tuberosum* L.), a highland South America domesticate, into Europe during the latter half of the sixteenth century. Nunn and Qian (2011) estimate that this species

J. R. Stepp (✉)
Department of Anthropology, University of Florida, 1112 Turlington Hall,
Gainesville, FL 32611-7305, USA
e-mail: stepp@ufl.edu

C. L. Quave (ed.), *Innovative Strategies for Teaching in the Plant Sciences*,
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alone was responsible for 25 % of the population growth in the Old World from 1700 to 1900. In Ireland, one variety of this single species became the main food crop for millions of poor farmers until potato blight spread across the island in the mid-1800s, destroying most of the crop. This was one of the factors in a complex political economy that led to starvation and emigration for millions of Irish. The transfer of food crops went both ways and several important European, African, and Asian domesticates were introduced into the New World, including bananas, citrus, rice and wheat.

Despite the historical significance of the Colombian Biological Exchange, knowledge of its effects has not entered the mainstream knowledge base of much of the educated public (Stepp in prep.). Undergraduate students for the most part are either unfamiliar with where important food crops originated, or their understanding of where they originated is incorrect (for example, assuming that pineapple originated in Polynesia when in fact it hails from South America). Courses in botany and ethnobotany can play a major role in enlightening students about the Colombian Biological Exchange, and the related topics of domestication and plant centers of origin (cf. Vavilov 1951; Harlan 1971).

In order to teach and reinforce some of these concepts, I developed a lesson plan for a 1491 Dinner. This can serve a stand-alone exercise or a point of departure for a range of other lectures on the topic.

10.2 Lesson Plan for 1491 Dinner

10.2.1 Instructions to Students

The year is 1491, one year before the date generally accepted as the beginning of European widespread contact and conquest of the New World. Your task is to research and prepare a meal for your fellow students, using only ingredients made from plants that are available in the region you select. These regions are: eastern North America, Mesoamerica, South America, northern Europe, Mediterranean, West Africa, East Africa, Middle East, northern China, Southeast Asia, South Pacific. (*Note to Instructors:* You may want to modify this list of regions based on the size of the course). Because the Colombian Biological Exchange (Crosby 1973) has not yet occurred, you must carefully research which plants are available in your region. For example, if you select the Mediterranean (e.g., Italy), tomatoes have not yet been introduced. In Southeast Asia (e.g., Thailand), there are no chili peppers.

10.2.1.1 For the Research Component

You should prepare a research paper on your chosen plants and describe what is currently known about their domestication and the larger context of agriculture in the region. Because the state of knowledge in this field is continually being updated, you should address current scientific debates related to your plants and region. Additionally, you should detail what is known about the migration of particular plant species in the hands of humans and what the impact has been. This paper should follow the same guidelines for research and citation as your other assignments.

10.2.1.2 For the Meal Component

Be creative and impress the class with your culinary skills. If you need space to prepare or heat the food beforehand, please let me know and I will help arrange this. There is no need to make a large amount, but use your best judgment in terms of portions so everyone can try your creation.

Important Note Exhaustively label the ingredients in your meal on a card. Because of the diversity of dietary preferences amongst students, please do not include any dairy or meat products in your dish. Also, do not use any groundnuts such as peanuts or tree nuts such as cashews. If you have a food allergy, please carefully review the contents of a dish before deciding to eat it.

10.2.2 Discussion

By focusing on particular regions, instructors can introduce students to the concept of plant domestication as well as centers of origin for important contemporary food crops. Students are often challenged to develop menus from regions where the present cuisine is heavily reliant on food crops that were introduced during the Columbian exchange. Take the tomato (*Solanum lycopersicon* L.) for example. Italian food today, and especially those dishes that have come to stereotypically define the cuisine abroad, is seen as reliant on this fruit from the Solanacaeae family. However, the tomato was only introduced into Italy sometime in the 1600s after Spain had conquered Mexico and plundered her domesticated crops. Likewise, the chili pepper (*Capsicum* spp.) is seen as synonymous with much of Thai cuisine. While the date of introduction into Southeast Asia is not certain, it is clear that it had a monumental impact that transformed foodways throughout the region. In 1491, a meal in Thailand would have been missing this component and black pepper (*Piper nigrum* L.) as well as other piper species would have fulfilled the role of providing a “kick” to a meal.

10.3 Experiences with the 1491 Dinner

I first introduced this lesson plan when I was a graduate student at the University of Georgia teaching my first course in ethnobotany. The class was mainly composed of anthropology majors along with a few ecology majors. Given the focus on human–environment interactions in the anthropology department there, the class was familiar with concepts of plant domestication and centers of origin but most had never thought about the historical implications and the impact on foodways that the New World–Old World collision brought into play. Students were fascinated to learn that many of the foods they routinely ate and took for granted had actually come from a particular region and, in the scale of human history, only recently been available globally. Since then, I have had the opportunity to present the 1491 Dinner to many other students in a range of settings from classrooms to informal field workshops. Some of the more memorable moments have come about when students have sought out relatively obscure plants and incorporated them into their menus, only to find that they did not exist in their chosen region in 1491. In every class, there are usually a handful of students with some cooking skills and they often work hard to ensure that they can still make a tasty meal out of a limited range of food crops by today's standards. Many students have reported enlisting friends and roommates in their endeavors who were not even enrolled in the course. The most elaborate menus have been developed during a short course in ethnobotany I teach at the University of Gastronomic Sciences (UNISG) in Pollenzo, Italy. UNISG is a new and dynamic undergraduate and graduate degree granting university that owes its origins to the work of Carlo Petrini and dozens of colleagues involved with the original Slow Food movement from the Piedmont region of Italy. The curricula bring in an innovative mix of gastronomy, agronomy, foodways, history, anthropology, ethnobiology, sensory ecology, food chemistry, and many other relevant disciplines. I should point out, though, that despite the focus on food the university is not a cooking school or culinary academy. However, some of the students come from a background in the culinary arts and hold impressive resumes with experience in some of the world's most innovative and renowned restaurants. As one might expect, students take to their assigned regions for the 1491 dinner with passion and innovation, developing elaborate menus from a constrained palette of fruits, vegetables, and spices. Both time constraints and sourcing issues make it impractical to actually prepare the recipes they develop but their ability to make the most out of a particular region's domesticates is impressive. Occasionally some plants find their way into recipes that clearly did not exist in a particular region in 1491 because the students could not bear to create a recipe that was missing their favorite ingredient! This leads to some memorable teaching moments and helps to reinforce many of the key concepts from the lesson plan involving plant migrations and human history.

10.3.1 Additional Related Activities

The diversity of plant-based foods sold in supermarkets has increased dramatically in the last decade. Foods that were considered "ethnic" or foreign have made inroads into mainstream American diets. The average supermarket provides an easily accessible field site for students to further learn about the origin of particular food crops. As a follow-up to the 1491 Dinner, instructors may want to assign students to conduct an inventory of all the fruits and vegetables found in the supermarket. Students can then look up where particular species come from. This not only serves to repeat and reinforce some of what they learned from the 1491 Dinner, it also exposes them to some plants that may not have shown up in the regional menus. For advanced classes (or intrepid instructors!), another possibility is assigning students to collect inventories in local markets that cater to immigrant communities. Students are often fascinated with the incredible diversity found at the local Asian, Latin American, or African food market. Due to the number of seemingly exotic species found in these locations, students might have difficulty in identifying everything they find. However, they will surely know the major food crops and part of the assignment could be for them to identify where these plants originally came from. Other related activities could involve interviewing market owners about their own knowledge of where particular plants came from and how important they might be to the contemporary cuisine of a particular region or culture.

Another way to modify the 1491 Dinner and potentially assess student's knowledge of the concept is to present menus and regions to the class and have students note which plant foods should be assigned to which region. This approach is a particularly good way to introduce some of the latest exciting findings regarding Polynesian migration and transportation of food crops using the example of the sweet potato. Scholars have known for years that the sweet potato was domesticated in the New World (although a debate exists as to the precise region) and thus assumed that its contemporary presence in the Hawaiian Islands was a result of Europeans introducing it. However, new genetic evidence has demonstrated that the sweet potato existed in the core of Polynesia by around 1200 CE, hundreds of years before the arrival of Captain Cook in 1778 (Roullier 2013). Given the extensive and complex maritime navigational culture in Polynesia, the introduction was likely due to Polynesians voyaging to South America and then back again, with the sweet potato in hand.

10.4 Conclusion

There are significant advantages from the experiential and hands-on learning opportunity that the 1491 Dinner provides over more traditional lecture-based formats. Students gain an appreciation for the diversity of the world's foods and a greater understanding of the process of domestication. They also learn about the huge historical impact, both positive and negative, that resulted from European contact and conquest of the New World and, subsequently, other regions that were colonized and transformed by the importing and exporting of food crops. They are introduced to a complex world where humans have continually modified their environments by bringing in new plant species. They gain a broader exposure to a number of interdisciplinary approaches in a variety of disciplines including agronomy, anthropology, archaeology, botany, economics, genetics, and history. Especially with regard to the latter, students get to know about the people *without history* (cf. Wolf 1982), the unsung and unknown people worldwide whose labors over many generations led to the domestication of so many important foods that we eat today. Ultimately, students learn the importance of the field of ethnobotany in bringing together and synthesizing diverse sources of information into a coherent discipline. I was recently talking to René Redzepi, co-owner and head chef at the restaurant NOMA in Copenhagen, Denmark. René's culinary explorations have, at times, relied on ethnobotany in developing a dynamic Nordic cuisine. When I mentioned that researchers and culinary professionals needed to collaborate more in order to introduce ethnobotany to a wider audience, he replied that we need to not only make ethnobotany relevant but also delicious! It is my hope that the 1491 Meal will help in that regard, while also providing a dynamic learning platform for students.

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Chapter 11
Teaching Plant Science in School and Community Settings

Lisa Carolina Gonzalez

11.1 Planning a Plant Science Program for Schools and Communities

An educational program in plant science begins long before the first lesson is executed with students. The planning process may take a few months or a few years. Teachers or outside agencies that are inclined to start or expand a school-based plant science program would benefit from first gathering information on the school or population including the current needs and resources of that particular community. Good program planning and design for school- and community-based sites should include these steps, which will be addressed further in the sections that follow:

- Gather data on the school or community population.
- Define the program audience and their current needs.
- Identify the goals and priorities of a school or community group.
- Write a program proposal.
- Choose or design the curriculum.
- Implement the program.
- Evaluate the program.

11.1.1 Gathering Data

Gathering information about the nature of a population is necessary to determine what types of programs will be meaningful for a particular audience. One of the first steps of planning is to do a literature review on the type of program you hope to implement. Since many programs require funding or approval from an administration, it is important to know how similar programs have benefited other populations.

L. C. Gonzalez (✉)
College of Agriculture and Natural Resources, University of Maryland Extension,
1114 Shawan Road, Cockeysville, MD 21030, USA
e-mail: lisacgo@umd.edu

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Referencing scientific and sociological research that confirms a similar program has measurable and quantifiable benefits can increase the likelihood of receiving funding and approval for programs. Next, it is important to get information about the community or school that will receive the program. A thorough internet search could include gathering information from local neighborhood organizations, school districts, and individual schools or community centers. It is also necessary to gather information from community members and stakeholders. This may include such methods as focus groups, surveys, community meetings, and individual meetings with stakeholders. Multiple methods should be used to get a clear picture of a potential audience and the best type of program to offer a school or community.

A *focus group* is a formal, small, planned meeting with prepared questions for a specific audience. Examples of specific focus group audiences could be parents of fourth graders, science teachers, urban farmers, or neighbors who live within 500 ft of a community center. Focus groups usually require preregistration and are often limited to only a few people. The participants of focus groups are usually rewarded with a small amount of cash, a gift card, or other incentive. Focus groups are quite formal and stick to a clear script of questioning.

Community meetings are much less formal than a focus group and usually do not require preregistration. Though the facilitator of the meeting may have specific questions they plan to address, the inherent nature of the community meeting is to solicit concerns and priorities from community members. Thus, a good community meeting leads to the discussion of topics that may not have been on the original agenda. There are no specific criteria for attending the meeting, and good facilitation of the community meeting can lead to future volunteers for gardening or horticultural projects.

Surveys can be distributed electronically or in hard copy form. Surveys could be emailed to members of a community organization or they can be sent home to all students' family members alongside the child's homework. The likelihood of response will be increased if surveys are brief, clear, and concise. Incentives, such as being entered into a raffle to win a prize, can increase response. Free electronic surveys can be created at such sites as surveymonkey.com.

11.1.2 Define the Program Audience

Grant funders like to see that an audience has a specific need that can be met through innovative programming. Some grant applications require such details as the total number of potential program participants and demographic information such as age, gender, nationality, and socioeconomic status of the people who will receive programming through their funds. Other critical information to describe in a grant proposal may be any outstanding needs of the community such as a particular health concern or high rates of gang activity among youth. Other facts that may be specific to a population could be whether or not the participants will have access to things like transportation, farmers' markets, affordable health care, or proximity to natural spaces. Here are some details to investigate prior to the design or implementation of a program that will help to better identify the audience:

- Age range of learners
- Ability range of learners (physical, intellectual, emotional, social)
- In-school or out-of-school learners
- Identify if the program is for students, parents, teachers, and/or community members
- Other demographic information (gender, ethnic affiliation)
- Language fluency
- Important cultural characteristics
- Socioeconomic indicators
- Primary environmental concerns of the community
- Primary public health concerns of the community
- Crime rates
- Access to natural spaces within the community or school
- Knowledge or skill base of audience with regards to botanical skills or food systems
- Access to grocery stores, farmers markets, or farm stands

11.1.3 Identify Priorities

Before the design and implementation of a school- or community-based program, the current needs of the proposed audience should be identified—particularly those needs that may be addressed through innovative programs based in the teaching of plant-based sciences. These needs vary from school to school but may include academic, family, social, and health needs. A *needs assessment* is a formal tool that could be used for large proposals that require significant funding from outside sources. However, even smaller programs should devote a period of time to gathering information about the needs, goals, and priorities of the target population.

Academic or curricular needs drive many education decisions at the local, state, and national level. However, programs that are implemented at community centers may find that the needs of an audience may be more individual. For example, a needs assessment may discover that a particular neighborhood lacks good affordable afterschool care options; thus, creating a program during the afternoon hours may be the best way to address the community's needs.

Aside from developing programs that work directly with students, programs aimed at providing teachers with the capacities to teach plant science or to contribute to programs that grow plants, are often well received. Teacher training and professional development are common needs found in educational centers. It is somewhat common for the teachers to be unfamiliar with basic concepts of botany and horticulture. A teacher training program that has been submitted to the state department of education and granted approval as a continuing education course offers more than just skills training for teachers; they can help educators maintain their certified teacher status. Whatever the needs of a school or community turn out to be, planning programs that meet the needs of a group is essential to the success of the program.

11.1.4 Write a Program Proposal

Educational programs at schools and community centers require a clear description of the program in the form of a program proposal. Proposals are necessary for administrative approval to implement programs and in order to submit grant applications. A whole chapter could be devoted to writing effective program proposals but to quickly summarize, good program proposals should include the following sections:

- Introduction
  - Definition of target audience
  - Description of needs as related to what the program offers
  - Research supporting this need
- Statement of goals and objectives
  - How this program meets the defined needs
  - Main goals of the program
  - Objectives to meet each goal
- Timeline
  - Specific dates for the planning, implementation, evaluation, and reporting of program outcomes
  - Budget timeline (when will funds be received, when will they be allocated, when will yearly budgets be submitted)
- Program format and design
  - Program methods and definition of educational philosophy
  - Units/modules
  - Lesson plans or activity plans within each unit
  - Development of supporting materials
  - Or if choosing previously designed curricula
    - Purchase rights to utilize
    - Seek administrative approval for use of curriculum
- Proposed budget
  - Funding sources
  - Specific plan for how funds will be spent

- Evaluation tools
  - Permissions to perform evaluations
  - Design of evaluation tools
    - Surveys
    - Pre-, then post-tests
    - Online system
    - Other methods

11.1.5 Designing Programs

After the informing phases of research and needs assessment are complete, program development and planning of specific activities or lesson plans can begin. It is not always necessary to create new curricula, as there are already numerous existing programs and curricula that are available. Many respectable organizations have created curricula and can be accessed from government or other educational websites. Table 11.1 describes many curricular possibilities. Whenever possible, evidence-based curricula should be utilized. *Evidence-based curricula* are a dependable source of educational material, as they are developed based on solid research and have been through a rigorous system of evaluation that includes a pilot phase where lessons are tested out with a sample of the target audience.

If an organization or graduate student hopes to create a new unique sequence of lesson plans for a specific program, they should complete all the steps previously mentioned, including an effort to understand the proposed audience, their needs, priorities, and resources. Lesson plans should be developmentally appropriate for the target audience; thus, an investigation into academic learning standards by age group is beneficial to the development of both in-school and out-of-school programs. A period of pilot testing lessons to gauge the levels of engagement and enthusiasm of participants can determine if any major changes to the curriculum are necessary before the printing of lesson plans and supporting material. Finally, evaluation tools should be utilized during the implementation phase to provide a base of evidence regarding the effectiveness of the curriculum in meeting program goals.

11.1.6 Implementation

The last step of program planning is the implementation phase of the program. This may include an initial period of training for those that will be actually doing the teaching of activities, including teachers, community leaders, or university students. Evaluation projects that accompany the implementation of the program can provide useful data about the benefits of the program and can be helpful if the program requires continued grant funding. The successful implementation of

Table 11.1 Plant science curricula by subject area[a]

Curriculum	Creator	Subject matter	Grade range
Schoolyard habitat project	US Fish and Wildlife Service	Designing habitat on school properties	1–12
National park curriculum	National parks	Most national parks have a curriculum available for educators which can be accessed at the national parks website: http://www.nps.gov/learn/curriculum.htm/	Varies
Project learning tree	American Forest Foundation	Trees, forests, and forest environments	PreK-8
Growing healthy habits	USDA—FSNE—University of Maryland Extension	Linking gardening with nutrition (full curriculum available at fsnep.org)	K-5
Grow it try it like it	USDA—FNS	Introducing new foods and growing foods for young children (full curriculum available at http://teamnutrition.usda.gov/Resources/growit.html/)	PreK-K
Junior master gardeners	Texas A & M Extension—4H	Curriculum series including units on plant science, nutrition, soils, garden-based literature, and wildlife gardening	1–8
Down to earth	North Carolina Extension—4H	Science-based gardening curriculum for clubs	6–8
Garden mosaics	American Community Gardening Association and Cornell University Extension	Science-based gardening curriculum that engages learners in action projects and interviews with gardening elders within the community	Ages 10–18
LIFE: Linking food and the environment	Columbia University Teachers College	A series of curriculum linking food and the environment	6–12
Teaching the food system	Johns Hopkins University—Center for a Livable Future	A food systems curriculum for high school (full curriculum available at http://www.jhsph.edu/research/centers-and-institutes/teaching-the-food-system/)	9–12
The great garden detective adventure		A standards-based gardening nutrition curriculum (full curriculum available at http://teamnutrition.usda.gov/Resources/gardendetective.html/)	3–4

[a] Numerous preexisting curricula are available for use by educators who wish to implement gardening and plant science activities with students at schools or community centers. This table lists curricula name, author, a brief description and the grade range of students the curriculum targets. Links have been provided for curricula that can be downloaded at no cost

a program requires many skills and capacities. The next sections of this chapter will focus on strategies for successfully implementing plant-based programs with schools and communities.

11.2 Teaching Plant Science in Schools

11.2.1 Creating Learning Environments Inside and Outside of the Classroom

There are many underutilized spaces around most educational buildings. In addition to adjacent fields and woodland, plant-based learning can take place in school courtyards, entranceways, and indoor spaces. There are hundreds of ways outdoor spaces could be used, but some common examples include native plant gardens, food gardens, therapeutic sensory gardens, or even a garden based on a beloved children's book.

To ensure the sustainability of a horticultural project, a team should be formed that will take responsibility for guiding the creation and maintenance of the space. Potential members for this team could include teachers, administration, maintenance, older students, parents, grandparents, volunteers, representatives from invested outside organizations, and university students. It is important to have enough members of the team to ensure that if one person leaves the project there are many more people to cover any necessary responsibilities. Likewise, recruiting new team members each year is essential to replace those that may leave later on.

Once the team has been identified, it is wise to refer back to the needs assessment to think critically about the physical development and use of the green space. Next, it is important to recognize the human, financial, and physical resources available to a school or community center when considering the size and scope of a plant-based project. It has been the author's experience that learning centers will often create spaces that are too large to be maintained in the long run. It is very important to be realistic about the time commitment team members can make to a garden. The phrase "start small" should be the mantra of initial team meetings. Once the successful maintenance of a program is established, then it is wise to consider expansion.

It will be essential to identify the resources that may be available for maintaining a botanical space. These resources include human resources such as teachers that implement lesson activities, teacher trainers, administration, maintenance crews, community volunteers, students, and university interns. How many hours a week that a teacher or community volunteer can realistically give to the maintenance of a garden or other living space needs to be discussed in advance. If the plant science program takes place during the school day, it may or may not be realistic to expect the teachers to be able to take the children outside. It is possible in some cases that the creation of an indoor horticultural learning environment is the most practical way to incorporate plant science into the curriculum. The intellectual resources, knowledge, and skills of those who maintain the living space needs to be assessed as well. One cannot assume that everybody has a basic knowledge of how to care for plants. In these cases, it may be helpful to provide training and/or a small library onsite with books or articles on topics that can be helpful to those implementing the program or caring for plants.

It is also important to consider the physical resources available to an educational location in advance of finalizing the site location. These resources include water, soil, space, and sunlight. In food gardens it is important to ensure that the water is potable (fit for consumption). Irrigation methods for any project could range from a complex system of drip irrigation to the use of student-carried watering cans. Soil is another resource that requires a considerable amount of attention. The soil found at the school or community center may not be of substantial quality to use for the type of project that is chosen. It may be necessary to bring soil in from an outside source or to get a soil test to check pH, nitrogen, and other plant nutrients, and in the case of food gardens, the presence of heavy metals or microbial pathogens. Light is another important variable to site design. Plants generally require full shade, partial shade, or direct sunlight. Fruit and vegetable gardens will require at least 6 hours of direct sunlight. Shade for participant gardeners should be available as well. Lastly, all plants have specific space requirements, so it is necessary to know how much space they require and thus to provide substantial space to the plants above and below the ground. Plants have unique requirements for water, soil, space, the amount of sunlight they prefer, and the temperatures they can tolerate. This information can be obtained from the internet, gardening books, or your local *cooperative extension* office, the community research, and outreach branch of the agricultural and natural resource departments of major land grant universities for each state. After the site is decided upon, it will be helpful to draw, with great accuracy, the layout of the garden or green space and to have this available to everyone who will help with the installation or care of the horticultural space.

11.2.2 Indoor Plant Environments

Indoor horticultural spaces may range from seeds planted in Dixie cups growing on a classroom windowsill to elaborate growing walls in the hallway. Projects that utilize a sunny windowsill are often convenient for teachers to work into the school day while providing a great learning opportunity for students. Some classrooms utilize more elaborate systems for growing plants indoors that may include the use of grow lights, hydroponics, or another sort of high-tech indoor growing situation within the classroom. These are often appropriate for schools that have a STEM (science, technology, engineering, and math) focus, agricultural programs, or an afterschool garden club.

Preexisting greenhouse classrooms in middle and high schools may be a great location to hold a class or after school club in the plant sciences. In previous decades, school systems had funds to hire a fulltime horticulture or botany teacher. However, due to widespread funding cuts these positions are few and far between. Thus, there are many schools across the country with underutilized greenhouse classrooms. These schools often welcome the idea of forming collaborations that revitalize and

Fig. 11.1 A simple experiment set up in a classroom window allows students to discover qualities about plants such as the germination process and a plant's requirements for light, space, and water

utilize these greenhouses. Lastly, there are many organizations that have educators willing to bring plant-based activities into the classroom. These include the state Agriculture in the Classroom Foundation, the Department of Natural Resources, the National Park Service, local botanical gardens, and other local educational organizations (Fig. 11.1).

11.2.3 Outdoor Plant Environments

A school extends well beyond the classroom doors. Within the boundaries of a school's grounds or adjacent properties there often lies incredible potential for horticultural educational spaces. These spaces can provide a venue for activities that reinforce academic topics in practical and experiential ways and can be linked to almost any aspect of the academic curriculum. In fact, the benefits to students may be much more far reaching than simply meeting academic needs. Some research suggests that outdoor learning spaces may also provide social and emotional benefits. A 2005 review article authored by two pediatricians describes the physical, emotional, and cognitive benefits of engaging in free play in outdoor environments including decreased rates of obesity, greater levels of emotional intelligence, and more opportunities to utilize parts of the brain that engage in problem solving, learning, and memory (Burdette and Whitaker 2005). Furthermore, maintaining outdoor spaces facilitates the development of social skills as it necessitates teamwork, patience, and responsibility from those who are involved. Outdoor spaces can also provide increased options for productive activities that a student may engage in during recess. Semi- or unstructured time can allow the students to develop skills in observation, inquiry, research, and communication of scientific phenomena. A healthy use of an outdoor botanical space would include both unstructured and structured (adult-led) time to explore the growing world outside.

The types of outdoor learning environments that can be incorporated into a school's property are manifold and will depend on the goals, needs, and resources of a school. A charter high school with a focus in environmental science may choose to create a garden for native plants or habitat creation. Undergraduate environmental engineering students can engage in a hands-on project to design an extensive system of rain gardens that deals with excess storm water on campus. A school or community center located in a food desert with high rates of obesity may decide on a large food garden in back of the property, utilized as a community garden for local families, thus providing a potential solution to their community's limited access to fruit and vegetables. Indeed, well-planned horticultural spaces in educational settings can provide meaningful solutions to community challenges in addition to providing a place where children can foster an appreciation of the natural world.

11.2.4 Utilizing the Natural Resources of a School Ground to Teach Plant Sciences

The natural resources of a school can range from one tree in the middle of an urban parking lot to a rural school with numerous fields and a large forest. The natural and biological sciences can be studied in these areas. Structured class time near a deep streambed or at the edge of a forest can teach great lessons about how energy flows through a natural system, how rocks are weathered by a stream's flow, what soil is made of and how organic and inorganic natural substances react with plants in a particular environment.

Outdoor resources can be utilized to teach core academic topics that students are expected to know within the plant sciences. Pollination and the parts of a plant are two of the main topics elementary students must understand about plants and can be taught from even one or two plants on campus. Older students can learn about the role plants play in providing habitat by taking a walk around the school grounds while younger preschoolers discover the seasons by consistently engaging in teacher guided observation while outside. A history teacher can educate students about how the Native Americans used certain plants and art teachers can engage the students in painting or drawing plants in their natural environment. There are limitless possibilities for the creative educator in using a school's existing natural resources to teach plant science.

11.3 Gardens as an Educational Modality in the School Environment

11.3.1 Food Gardens: Teaching Food Systems and Nutrition

School food gardens provide numerous benefits to students and their families. One of the greatest benefits of a food garden is its potential to promote an increased consumption of fruit and vegetables among the school body. Working in the garden is naturally engaging to students and can lead to an enthusiasm for trying the garden-

Fig. 11.2 First-grade students visit a thriving raised bed vegetable garden during a school day in June to harvest vegetables for a cooking class led by their science teacher

grown produce. Gardens also support nutrition education by providing produce that can be used to teach students about food, cooking, and food safety skills. New innovative programs in schools set up community garden plots for families where they can grow their own free produce. When these school gardening programs are coupled with nutrition education and/or cooking classes a school garden can also fill a need to provide health literacy and food preparation skills to school families. Some school gardeners are even donating produce to food banks or practicing entrepreneurship through selling their crops at school and community farm stands/markets.

There are widespread gaps among students throughout the grades in their understanding of food systems, agriculture, and food's effects on the human body. It is not uncommon to find that students do not know very much about where their food comes from and certainly not what a tomato or zucchini plant looks like or the conditions required for their growth. Furthermore, many students lack an understanding of the importance of eating a variety of fruits and vegetables to ensure adequate intake of all the different vitamins, minerals, and phytochemicals. School food gardens can teach knowledge of growing plants, agricultural ecosystems, nutrition, the history of certain foods, and the culture of eating (Fig. 11.2).

11.3.2 Gardens That Teach Ecology: Native Plant, Pollinator, and Rain Gardens

There is a great focus among standards of learning for middle and high school students to engage in activities that help them understand natural systems, the interrelationships of species, and the flow of energy within an ecosystem. There are many ecosystem-themed gardens that can be created on a school's properties that allow hands-on investigations of these biological phenomena through the study of a garden ecosystem. Table 11.2 describes some examples of garden themes based in ecology.

Table 11.2 Ecology-themed gardens[a]

Learning goal	Type of garden	Further applications
Pollination and insect/plant interactions	Pollinator habitat garden	Insects in agriculture: the use and effects of pesticides, integrated pest management (IPM) techniques, plant pollination (flower to fruit to seed, parts of the flower)
Native ecosystems	Native flower garden, examples of eco-systems (wetlands, meadow, or native forest species)	Native habitat ecology: wetland ecology, forest ecology, prairie ecology, native wildlife, invasive species, environmental science
The flow of matter and energy in an ecosystem	Composting project	Soil composition, soil ecology, soil organisms, leaves to soil
Environmental stewardship	Rain garden	Storm water in the environment, erosion, aquatic ecology

[a] This table provides some ideas for school-based projects that can be utilized to teach lessons in ecology

11.3.3 School Gardens: Common Challenges and Their Solutions

Maintaining a community- or school-based horticultural space takes a lot of hard work, effort, and good organizational skills. Their care falls outside of the job description of most school faculty and staff including custodians. Many schools and community centers attempt to start gardens and unfortunately are unable to care for them in the long run due to other time commitments. It is not a mandatory part of the curriculum to learn about gardening and so the student body may or may not feel responsible for caring for plants or pulling weeds. If planning is not in line with academic goals, lessons that connect the students with plants will often be replaced with activities linked to subjects that students are normally tested on. Therefore, creative strategies for utilizing these gardens are essential to their success and long-term sustainability.

Plant science programs are frequently implemented at schools by outside organizations. As discussed above, assessing the needs and resources of a school, learning center, or larger district is necessary to ensure successful implementation of any plant science program. There are numerous examples of well-meaning organizations providing an extensive garden or landscape to a school without assessing the commitment and resources available or how it fits into the academic framework of the district. After the work is done and they have left the school, these programs can fall by the wayside as busy teachers are likely to focus on other, primarily academic, priorities. By initially assessing a school's needs and resources, one can plan and implement a plant science program that engages the school community from the start and one that ensures the continued maintenance of a horticultural space.

A successful program in plant science requires building the foundation for a strong and lasting collaboration with a school. Whether the program creator is a teacher, parent volunteer, graduate student, or college professor—it is always best to introduce educational projects to a school that are the result of solid teamwork and common goals. Preliminary meetings with school officials and other stakeholders, followed by a community meeting, are a good place to start, followed by the formation of a garden team. All of these steps are necessary to build a solid foundation for a strong gardening program.

One last common challenge that school gardens face is the fact that bringing children outdoors can lead to more challenging behavior than often found in more formal classroom settings. By anticipating common behaviors or reactions students may have outdoors and proactively coming up with solutions, a teacher or even an undergraduate student intern can avoid some common challenges of taking children outdoors to learn. Here are some final tips for how to engage students outdoors in gardening projects:

- Utilize a curriculum to provide structure to time spent outdoors.
- Work together with students to create a list of rules and discuss these before going outside.
- The list of rules should include guidelines for walking to/from the garden, acceptable volume levels, and what tasks can or cannot be done by students.
- Have a plan so that every student can be involved. Students that are bored can be very disruptive.
- Have enough tasks to engage all the participants. Be clear about directions for each task.
- Provide a substantial amount of tools and be clear about the process for taking turns using them.
- Take the time to show students how to use, travel with, and store tools.
- Have enough seeds/plants so that everyone can participate.
- Seek help and assistance from volunteers, other adults, or even older students.
- Create physical structures to illustrate garden boundaries (raised beds, borders, mulched paths) to avoid children stepping on plants.
- Allow time in the schedule for students to experience the garden at their own pace. This can be the time for them to follow butterflies or learn about worms without being rushed.

11.3.4 Linking the Plant Sciences to the Core Academic Curriculum

One way to increase the success of a school garden is to link it to the academic curriculum. School districts may or may not have an approved curriculum, or sequence of lesson plans and activities, for use in teaching horticulture or other plant sciences. If there is an existing curriculum, it can often be accessed by asking the district director or coordinator of science, horticulture, or STEM. Learning standards can also often be found at state department of education or local board of education websites. States have common core curriculum standards that provide a general guide for each county or parish with every district deciding more specific standards including a timeline by which certain topics should be taught within the curriculum.

The National Next Generation Science Standards were released in 2013 and provide the structure for many districts across the country. If an educator at a school would like to incorporate more activities in the plant sciences it would necessitate an investigation into the standards of learning for their district and state. A teacher can likely find existing curricula and lesson plans on a particular unit to get some ideas for activity plans, or the teacher may choose to create original lesson plans, making sure that they are in line with their district's standards.

Academic standards of learning describe the expectations of students regarding particular topic knowledge and academic skills. Standards of learning for science, math, art, literacy, comprehension, history, health, foreign language, and physical education are fairly universal. Subjects such as horticulture, environmental studies, agricultural education, and STEM may or may not be part of a district's standards of learning. The grades in which certain subjects are taught often differ state by state and sometimes even by county, depending on the standards. For example, pollination in one district may be taught in the fourth grade while in another district it is introduced as early as second grade. It is important for teachers and for agencies implementing school-based programs to design activities within the structure of these standards. This ensures that the children have the foundational knowledge to understand important concepts. Table 11.3 describes a selection of core standards from the Next Generation Science Standards for some key concepts students must grasp. More specific details are described by state or local districts.

The ease of implementing a plant science program in a school often depends upon the amount of detail within a particular district's curricula and standards. In districts where there is little wriggle room in the curriculum, it is essential to adhere to the standards of learning and especially to tailor programs to address a gap in the curriculum. Some classrooms do have less curricular restrictions and more space in the school day to incorporate plant-based activities. Younger grades such as preschool through kindergarten generally have a less restrictive curriculum and are less likely to participate in statewide academic testing. Private schools also tend to have more flexibility with their curriculum. Private schools may follow a particular educational philosophy and often have their own national standard-determining curricula. Some private schools, for example, Waldorf or Montessori, have a curriculum that strongly promotes and encourages a child's relationships with the natural world of plants.

11.4 Teaching Plant Sciences in the After-School and Summer Camp Environment: Making Learning Fun

Due to the time constraints most teachers face, they may find it challenging to incorporate a substantial amount of plant-based activities into the classroom. Outside organizations with great intentions to offer a program in plant sciences to schools may find that other academic needs make it impossible to incorporate new programs into

Table 11.3 Science standards and plant science activities[a]

Standard or learning goal	Sample activity
Planning and carrying out investigations	Compare plants grown in full sun, shade, and partial sun to determine a plant's specific light requirement
Analyzing and interpreting data	Plant 50 seeds and see how many germinate. Repeat experiment with multiple species
Use observations to describe patterns of what plants and animals need to survive	Lead students on monthly walks around the school grounds, providing accompanying journals to describe their observations
Engaging in argument from evidence	High school students learn about food and the environment through a mock debate where students form partners, choose an agricultural environmental issue and communicate their position
Biogeology: How plants and animals change their environment	Students learn about invasive plant species through lectures and an accompanying walk to a local park
Natural resources	Students learn about the life cycle of a pine or oak tree and the practice of forestry. Students find acorns and pine seeds, observe them, and attempt to germinate them
Conservation of energy and energy transfer	Students learn about photosynthesis through experiments with ornamental plants in their windowsill
Structure and function of organisms	Students visit a school garden and draw a plant, labeling its parts
Obtaining, evaluating, and communicating information	Students read a book about a school garden and come up with a plan for designing a garden outside their classroom door
Energy and matter	Students rake leaves and compost them
Growth and development of organisms	Students keep a daily record of a seedling's growth over the course of a month
Inheritance and variation of traits	High school students recreate Mendel's pea experiment
Interdependent relationships in ecosystems	A class plants milkweed, a butterfly attractant, watching butterflies lay eggs and caterpillars eat the leaves of the milkweed
Biodiversity and humans	Students compare the amount of animals in an interior courtyard to an adjacent field
The roles of water	Students learn about the water cycle and transpiration in plants through an experiment in class
Asking questions and defining problems	Students in a garden club problem solve to find a solution to weeds in the garden
Scale, proportion, and quantity	Measure the weight of produce grown from one seed
Systems and systems' models	Map out how the food gets from farm to table
Science is a human endeavor	Biotechnology and the engineering of plants
Life cycles and traits	Kindergarteners learn about the lifecycle of a cherry tree to discover qualities about the seasons by visiting a cherry tree and by hanging a branch in the classroom that is bare or decorated with cherry flowers or leaves depending on the season
Matter and energy in organisms and ecosystems	Students learn how energy moves from the sun to the plant to the animal that eats the plant and back to the soil

[a] This table lists science standards (as described in the National Next Generation Science Standards) and suggested activities in the plant sciences that can help students meet learning goals for a particular standard

the school day. After-school or summer programs do not have such restrictions and may offer a great opportunity for collaboration. However, it is important to recognize that educational strategies will need to be adapted for these more relaxed settings.

Working with youth in after-school and summer camp programs is quite different from working with students in more formal classrooms. During a normal school day, students understand that there are certain expectations about the nature of the work that must be done and the need to remain quiet. Once the school bell rings or during the summer break, students are naturally more energetic and rambunctious and need healthy outlets for this energy. After a long day of structure and hard work, most students want to relax, play, or enjoy meaningful projects. Students may show some resistance if they are expected to do something that they perceive as similar to schoolwork such as completing a work sheet or listening to a dry lecture. Therefore, it is important that programs that teach plant science during these times are full of fun, highly interactive projects.

There are many widespread after-school and summer learning centers that are responsive to offerings in community programming involving horticultural and botanical education. These community centers provide natural opportunities for partnership in implementing programs. For example, professors seeking to create teaching opportunities for graduate students in plant sciences may find it easier to collaborate with community centers during *out-of-school time* or summer-based/after-school programs. Aside from public summer school programs, these youth centers may be open to collaborations for implementing programs in plant science (Fig. 11.3):

- Parks and recreation
- 4H (managed by the county cooperative extension office)
- Religious camps or daycare
- Girl scouts / boy scouts
- Girls clubs / boys clubs
- Botanical gardens
- YMCA and YWCA
- Future Farmers of America (FFA)

11.5 Teaching Plant Science in Underserved Communities

Teaching plant science in underserved communities has the potential to fill many great needs commonly associated with economically disadvantaged neighborhoods. Urban farms and community gardens offer an opportunity to increase access to healthy produce, better nutrition, and they can serve as a venue to teach agricultural skills. Projects that include the installation of green spaces have great potential to serve the emotional and public health needs of communities. University students offer the human resources and physical labor that are often less available in economically disadvantaged communities. This section will explore some creative programs specifically designed to meet the needs of underserved neighborhoods.

Fig. 11.3 A container-grown vegetable garden growing outside a community center provides opportunities for students to engage in a variety of meaningful activities, including a cooking and gardening club, during after-school time

11.5.1 Collaborating with Community Gardens and Urban Farms to Teach Plant Science

Horticultural programs in limited income communities can offer innovative solutions to the increasingly growing nutrition and health needs of people facing socioeconomic disadvantages, particularly those living in food deserts. A *food desert* refers to a place where there is limited access to healthy foods. Recent research suggests residents of food deserts have an increased likelihood of obesity, diabetes, cardiovascular disease, malnutrition, and other diet-related conditions. Fortunately, numerous innovative programs have been initiated to address this growing concern.

One promising solution to the crisis of food deserts are urban farms and community gardens which increase access to nutritious locally grown produce for community residents. Coupled with a nutrition education program these gardens and farms can offer programs to teach people how to choose, grow, and prepare healthy, nutritious foods. Innovative community programs engage residents in hands-on activities that build skills for healthy behaviors, such as eating more vegetables and the physical activity of gardening. Urban farms and community gardens are often willing participants in research and can provide a location to conduct graduate research projects that study, for example, agriculture, health behavior change, or food systems (Fig. 11.4).

11.5.2 Utilizing Parks and Live Plant Collections to Teach Plant Sciences Within the Community

Many people living in metropolitan areas do not have the opportunity to have regular and meaningful experiences with plants. It is rare to find people with the skills necessary to identify plants, care for their growth, or understand their biology. In urban areas, this is an even more likely situation. Many people, including residents

Fig. 11.4 An urban community garden provides a source of healthy fruits and vegetables to residents living in food deserts. Community gardens that offer nutrition education and cooking classes can additionally teach residents how to cook and prepare healthy dishes. Community gardens also offer a location for agricultural skills training programs for new or future urban farmers

of metropolitan areas, can benefit from experiencing plants in parks and live plant collections. Numerous skills in identification, nomenclature, taxonomy, and ethnobotany can be gained by participants. Usually, it is fairly easy to coordinate a group visit to these sites. Further inquiry may reveal that there are even classrooms or projectors available for rent. These sites can often be a perfect location for a class that teaches horticultural skills or for a garden club group. Access to the site, a classroom or other structure may require some paid fees or a large group permit. It is important to work out the logistics before arranging any programs or tours. Community-based plant science programs that meet on a repeating basis can visit multiple sites to learn about plants or develop skills in botany. Table 11.4 describes some ways to utilize these locations to teach plant science.

11.5.3 Revitalizing Communities Through Greening and Horticultural Initiatives

Urban communities all too often lack sufficient natural green spaces, so projects that include planting trees or installing a garden or other permanent landscape feature can provide profound impacts to residents. Though educationally based plant science projects may not be able to provide solutions to all environmental or public health problems, with careful planning they certainly do have much to offer communities. Residents are not always aware of such environmental concerns, and if they are, they may not hold the knowledge, skills, or resources to do anything about the issue. Innovative programs can be created to meet this need.

Environmental concerns can include indoor and outdoor air pollution associated with urban environments. Greenery in the form of indoor plants or tree plantings outside can help with cleaning the air people breath. Another environmental concern in urban areas is the accumulation of toxic metals in the soil. Bioremedia-

Table 11.4 Utilizing live plant collections[a]

Venue	Skills learning
Arboretum	Plant families, nomenclature and taxonomy, plant identification, economic botany, principals and skills in forestry
Conservatory	Tropical plant ecology and identification, ethnobotany, botany
National and state parks	Natural history through the seasons, ecosystem ecology, wildlife biology, plant identification skills, botany, wild edible foods, wild medicinal plants, invasive plant identification
Wildlife conservation areas	Wildlife biology, native plant identification, natural history, insect/plant relationships, conservation biology
Personal property	Ornamental plant identification and care, medicinal or edible plant identification and gardening, vegetable garden tours and skills workshops

[a] This table offers some potential plant science topics that can be taught at the sites of live plant collections

tion is the study of how to restore contaminated soil. Bioremediation includes using plants that can pull toxic metals or other contaminants out of the soil. Contact the Environmental Protection Agency, local cooperative extension office, native plant society, Master Gardener chapter, or other environmental nonprofit agency to learn the species of plants that grow in a specific region and that can be used for such projects.

Another environmental concern that can be addressed through innovative plant education programs is the issue of excess storm water runoff. Storm water runoff can include pollutants such as eroded soil, fertilizer, pesticide, and automobile fluids that ultimately end up in water bodies like rivers or bays. Solutions such as rain gardens and the use of rain barrels are gaining popularity throughout the country. Unfortunately, most people do not have the knowledge or skills to implement these landscape features. However, this does provide a great opportunity for the implementation of new programs to address this concern.

11.5.3.1 Example of Community Rain Gardens

In Baltimore County, Maryland, the Gunpowder Valley Conservancy (GVC) has an innovative program model to teach people skills in building rain gardens. GVC identifies properties bordering streams and rivers where storm water drainage has a profoundly negative impact on the aquatic ecosystem. GVC works with the homeowner to arrange a free rain garden workshop on site. GVC uses grant funds to pay for half of the expenses of the rain garden (such as native plants and tool rental) while the homeowner pays the remaining costs. Community members come to the site to first learn about the need for rain gardens as well as important principals of the design process. In return for the free workshop, they provide the labor for the installation of the rain garden. This is just one example of an innovative program and examples of other programs can be found throughout the country.

11.5.4 Empowering Community Leaders Through Horticultural Skills Trainings

There is growing interest among people of all ages in acquiring the horticultural skills necessary to grow plants that have economic value. Agriculture, sustainable forestry, horticulture, permaculture, and landscape design are some examples of fields that utilize the growing of plants for economic returns. Training programs that lead towards certifications in these fields provide a valuable service to trainees. Training programs with older high school, college students, or recent graduates can provide skills training to help them create a better environment in their neighborhoods while hopefully building capacities that help them to secure work. These training programs are especially needed in limited resource communities where job opportunities are scarce. These neighborhoods often lack sufficient green spaces or could be considered a food desert; thus, horticultural skills training programs can make profound impacts on multiple levels.

11.5.4.1 Case Study: Baltimore, MD

Within the urban landscape of Baltimore City, Maryland, young people are becoming interested in urban agriculture as a means of bringing more healthy produce into the city for residents. These young farmers are working together to learn how to grow in a safe yet productive manner. They have formed an organization to support the training and economic effectiveness of these farmers called the Baltimore Urban Farm Alliance. The alliance offers a training program for urban farmers covering such topics as understanding city laws and regulations of land use, urban soils (testing and remediation), composting, mushroom farming, animal husbandry in the city, starting seeds, food safety, transplanting, and inviting youth to the urban farm environment. The University of Maryland Extension, in collaboration with the Chesapeake Association for Sustainable Agriculture, offers a certification program for beginning farmers that covers similar topics in more depth and additional topics such as installing drip irrigation, marketing produce, and utilizing high tunnel hoop houses to extend the growing season. Within the first few years of the program, more than 100 people have been trained with the skills to start an urban farm.

11.5.5 Using the Internet and Social Media: Connecting Communities to Plants

The internet and social media websites provide another way to connect communities to plants and to innovative programs available to the community that teach skills in plant science. *Social media* is a relatively new term that describes a web page or other form of online cooperative where individuals or groups can create a unique account or web page within the framework of the particular social media outlet. In this setting, individuals can connect and interact with the pages of others who share similar interests in plants; sharing pictures, promoting upcoming events, or discussing topics of interest. These individual social media pages can be shared and utilized with other people with varying levels of privacy determined by the individual or group account holder.

Social media may prove very useful for community-based plant science programs (Table 11.5). Organizations, groups, and educational venues can maintain a page or site to promote their programs or events and to stay connected with potential clients or group members. For example, a local garden club, Master Gardener group or classmates in a university botany program can stay connected, discuss events, or share pictures of a plant they need help identifying through such sites as a group Facebook page or a Google+ circle. A naturalist or botany student that wants to give an edible and medicinal plant hike could promote their offering through multiple social media sites. One benefit of using social media to advertise programs is that your Facebook friends or Twitter followers, for example, can with one click of a button share your advertisement with all of their online connections. Research programs can utilize social media to recruit human participants. Additionally, social media can allow groups of people to continue communication between in-person meetings including to remind members of upcoming volunteer workdays or to quickly share news of the identification of an invasive pest in a specific area. Lastly, social media provides people that cannot meet as a group with a mode of communication. This may include people that are in different geographic locations (such as teachers in multiple states who lead gardening programs) or those with limited mobility such as aging adults or physically disadvantaged individuals.

Social media sites are even providing training programs online using technology such as Adobe Connect, TedX or even video sharing sites such as YouTube. One can learn many horticultural skills on YouTube or other video-sharing websites. There are short videos on almost every topic from starting seeds to how to harvest and prepare dandelion roots. Some sites provide a series or sequence of videos, online lectures, assignments, and interactive chat sessions that lead to a certificate, or even a degree, in such topics as herbal medicine, plant identification, school gardening and ecology.

11.6 Providing Service Learning and Student Teaching Opportunities in the Plant Sciences for High School, College, and University Students

Community and school programs that incorporate action projects that include gardening or other horticultural projects offer a symbiotic opportunity to older high school or college students. Through collaborations such as these, communities in need of volunteers are served by older students that seek a service learning or internship experience. The benefits are received by both parties. Even 1-day projects can be profoundly impactful to these older students in addition to the communities they serve. Furthermore, students can gain valuable skills by being involved in the design and planning of these horticultural spaces.

Table 11.5 Social media and plant science programs[a]

Social media site	Description	Ideas for plant science programs
Facebook	Site where individuals or groups can create accounts and share status updates, pictures, short videos, flyers, posters, and links to external websites. Individual Facebook users can connect as "friends" and users can connect with groups by "liking" a group Facebook page	Separate pages can be set up for events and offer a great way to invite and promote educational community events. A program can create a unique Facebook page to stay connected with members. Members of the Facebook group can post pictures and start discussions about specific plants, their pests, or how they grow
Twitter	Personal pages created for a group or individual. Twitter has one feature, which is the status update and is limited to 140 characters or less. By "following" another page you get all of their status updates	By using the hashtag (#) people can have a conversation on twitter. For example #agchat is a weekly event on twitter where people in the agricultural field connect and have a discussion on any number of topics. By including #agchat in the status update everyone else in the conversation can view your comments and offer a reply. Another useful feature is the "retweet" where an individual or group can share another's post with all their followers. Follow the chapter author @lisalettucelady
LinkedIn	This site connects professionals in similar fields. An individual's LinkedIn page lists such things as work history, skills, and education. One's "connections" can then endorse a person's skills and experience	This site sends emails about job announcements within certain fields and is a good place to advertise open positions. Multiple "connections" can communicate through LinkedIn groups that send regular emails to members of the group on a related topic
Pinterest	This site can be thought of as an online bulletin board sharing system. An individual creates a page and "pins" things they see on other's pages that interests them	This is a great way to share project ideas such as how to build a raised bed, how to design a pollinator garden, or how to grow potatoes out of tires. You can also post pictures of flyers to promote upcoming programs
Instagram	This is a photo-sharing site	This is a great way to share pictures of projects or events with your clients or participants that are also on Instagram
Weebly	This is a site for building a free website and can be password protected to limit access	This is a way to share information between group members without allowing the public access. Alternately, it can be used to host a website for the public. The author's website is hosted on weebly and can be found at http://www.growingintowellness.com/

Table 11.5 (continued)

Social media site	Description	Ideas for plant science programs
YouTube	Video-sharing site	Some organizations upload educational videos to this page to teach horticultural skills such as how to make a biodynamic fertilizer preparation or how to set up a rain barrel irrigation system
TedX	This is a video-sharing site that is strictly for uploading free lectures	This is great for people that have something they would like to share with the world. TedX lectures can be on topics from growing your own food, to saving heirloom seeds, or the details of pollination biology

[a] This table describes some of the more commonly used social media sites and potential applications that support plant science programs in communities

Fig. 11.5 The chapter author and a master gardener working in a community youth garden

Setting up a collaboration where older students have the opportunity to teach and/or mentor children on a more regular basis gives valuable experience and life skills to older students, including future environmental educators and teachers, while also providing excitement and enthusiasm for the younger learners. Other undergraduate or graduate students that may be more interested in community development, environmental engineering, public health, or nutrition can find meaningful long-term internships by organizing, coordinating, and implementing projects that impact communities in a positive ways (Table 11.6 and Fig. 11.5).

Table 11.6 Plant-based projects for older students[a]

One-day projects	Long-term internships
University students participating in an orientation day can build and plant a native plant garden at a local school	Graduate students design an environmental education curriculum for sixth graders with nine monthly lessons on the topic of native and invasive plants. Students teach sixth graders nine native plants and nine invasive plants as well as teach about how these plants interact with other species in the environment. The program ends with a culminating project where all participants work together to build a native plant garden
Graduate students build eight raised beds for a community garden	A graduate student helps a community navigate the legal process of starting a community garden over the course of a semester culminating in the graduate student producing a manual describing the land use laws for a district, the process by which one would get the proper permits, and lists contact numbers for residents
An urban vegetable farm hosts undergraduate agriculture students for a volunteer work day	The undergraduate program and the urban farm create an intern contract, allowing two students per year to work 10 hours a week on the farm
Undergraduate education students go into third grade classrooms to do a seed planting project	Undergraduate students help start and run a weekly afterschool gardening club in collaboration with school teachers
High school students plant trees at a local recreation and parks afterschool center	High school students in an environmental club grow trees from seeds in a greenhouse and with the help of their teacher, arrange tree plantings at a different recreation office every month
A local cooperative extension agency gives a 1-day workshop on rain gardens	A local cooperative extension agency designs a 4-week course leading to a certification in Rain Garden Design and Installation
Undergraduate students volunteer at a local farm during a school field trip	Undergraduates build raised vegetable beds and help the school plant and harvest vegetables throughout the year that are donated to a local food bank

[a] Plant science projects implemented by college students or interns can occur over the span of one day or multiple semesters. This table describes various suggestions for short-term and long-term projects that offer older students meaningful experiences in teaching plant science.

11.7 Conclusion

In conclusion, there are many types of collaborative projects in the plant sciences that can engage schools, communities, and university students in meaningful and impactful activities. These projects are most successful when they are carefully planned and take a community or school's needs and resources into consideration. The use or development of curricula that are evidence based and in line with academic standards of learning increase the likelihood that plant science programs will be successfully incorporated into a school-based program. Different strategies and methods may need to be used with programs that work with adult community members, classrooms, or students during out-of-school time. Botanical projects can incorporate the use of high school, college, and university students for one-time events or can provide a source of valuable long-term experiences or internships. Wherever the plant science education takes place, it is always helpful to form and work with a team that takes responsibility for guiding the program and caring for horticultural spaces. Engaging students in horticultural programs during the school day, starting a garden club at an afterschool center, developing a skills training program or creating a thriving urban community farm can be challenging and time consuming. These innovative projects are well worth the effort and can provide incredible benefits to both the communities that receive the programs and the people implementing them.

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Chapter 12
Using Community Resources for Ethnobotany Courses

Al Keali'i Chock

12.1 Introduction

12.1.1 Ethnobotany

Ethnobotany is the study of interrelationships of plants with people, both in ancient and contemporary times. Many people think that it only includes past activities of people and plants, and while this concept was true a century ago, and consists of a large segment of our studies, ethnobotany also includes the adaptations that people continually make to the "old culture" with regards to their interactions with plants. Adoptions made by people considered to be "outsiders" are another aspect.

Hawai'i, for example, is a place where many different and diverse ethnic groups came together more than a century ago to work in the sugar and pineapple plantations. Some of these peoples may look somewhat alike to "Western" eyes, but historically many were adversaries, even within what some consider as a single ethnic or racial group. For example, the Punti Chinese would not intermarry with the Hakka Chinese a half century ago; today this is no longer true. The thought of adopting parts of the other culture, such as food, may have initially had an antipathy, and given rise to some very difficult situations. There were also instances of discrimination by those in plantation management, and the imposition of what some writers have called "colonization." Over time, however, especially with the welcoming attitude and characteristic of island societies (e.g., the Polynesians who settled Hawai'i in prehistoric times), it has resulted in an amalgamation of the modified host culture, changed and blended with the more recent immigrant groups, into a new, so-called

A. K. Chock (✉)
Department of Botany, University of Hawai'i at Mānoa, 3190 Maile Way, St. John 405D, 96822-2279 Honolulu, HI, USA
e-mail: alchock@hawaii.edu

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"local culture." More than half of the marriages in Hawai'i are "inter-racial." Some[1] may find that the attitudes toward race or ethnic origin are very different from the norms found in, for example, the mainland US local people will ask "what you are," and designate words to categorize you. Some newcomers find this offensive. This question can be traced back to the meeting of different island peoples (at least in Polynesia), when the newcomer would recite his genealogy to indicate who he/she is. The resident would then respond with his/her origins. Often, they found some common ground in a few prior generations, and after that has been explained, they may consider themselves "related."

12.1.2 Community Resources

Perusing several dictionaries, I found that the word *community* is derived from the Latin word, *communitas,* and means a fellowship or organized society group, which is demarcated by natural or artificial limitations or boundaries. These two factors are further explained:

- Natural: delimited by ethnic, cultural, geographical barriers
- Artificial: political boundaries, which can be very arbitrary, and do not consider some of the natural limits

The second word, *resources,* is also derived from Latin, *resurgere* (to lift up, rise again, reappear, surge), and has a wide number of different specific, but similar, definitions, such as raw materials, minerals, commodities, capabilities, and funds (e.g., collective wealth of a group or other available assets found in a group).

In the context of teaching plant sciences, this term, *community resources,* refers to the available facilities and venues which are available in local, regional, and national institutions, activities, festivals, markets, trips, exhibitions, and events which may be used to increase, facilitate, expand, or supplement the knowledge of ethnobotany (the interrelationships and interactions of plants and people). Many of these groups in the twenty-first century have websites or are cited by a travel guide or review, and can be found in your location by using an Internet search engine; you should then visit the venue to determine how it can fit in your course, and develop practical and useful study questions. Some of the study questions that we have used are indicated in the examples in Sect. 12.3 of this chapter. You may wish to use these ideas as "starters" in your classes.

[1] There is the saying, "When in Rome, do as the Romans." This context could also be applied to newcomers to any society. The point here is not to try to impose your views or beliefs when you go somewhere else, but to try to understand the culture or society to which you have come, as a newcomer. Appreciate the differences, even if you find them unacceptable.

12.2 A Brief History of Ethnobotany at the University of Hawai‘i

As the University of Hawai‘i at Mānoa (UHM) was the first university to offer an undergraduate major in ethnobotany, a number of my colleagues have asked me to summarize the development, evolution, and expansion of ethnobotany instruction in Hawai‘i. Since the first ethnobotanists in Hawai‘i were the Polynesian settlers who discovered this island archipelago more than a millennium ago, I made the following translation to describe and define ethnobotany in the Hawaiian language. I sent the proposal to Naomi Noelani Clarke Losch[2] who was my language instructor at Leeward Community College when I studied it the second time[3], after the universal adoption of the diacritical marks as an aid to pronunciation for correcting and editing. She concurred with my proposal for a contemporary translation of *ethnobotany* (Losch 2008), as:

‘ike no‘eau nā lā‘au like ‘ole o nā kanaka.

For the benefit of those who are not familiar with the Hawaiian language, this translation comes from several different words (Pukui and Elber 1986):

- *‘ike* which can be translated as *knowledge* (or understanding and comprehension, and thus learning)
- *no‘eau*[4], as *expert*
- *nā* is the plural definite article, *the*
- *lā‘au* means *plants*
- *like ‘ole* is different or various (*like* means same, while *‘ole* is a negative modifier)
- *o* is the preposition *of*
- *nā kanaka* is the plural of *people*

[2] Associate Professor of Hawai‘i Language (now retired), UHM. Mrs. Losch and three others were honored on March 18, 2011 by the *Hawai‘inuiākea School of Hawaiian Knowledge* with the *I Ulu I Ke Kumu* award for extraordinary commitment and excellence in Native Hawaiian Education.

[3] While no longer fluent in the Hawaiian language, I first studied it formally before the adoption of diacritical marks as an aid to pronunciation, which was espoused by the second author of the Hawaiian Dictionary, Samuel H. Elbert, a renowned linguist who first learned Tahitian.

[4] In Hawaiian grammar, the adjective or modifiers come after the noun, instead of before, as in English. *No‘eau* can also mean *wise,* as in the collection of Hawaiian proverbs in a book by Mary Kawena Pukui, entitled *‘olelo No‘eau*. Since the glottal stop or ‘okina (‘) is used to represent a missing consonant, which in most cases, linguistically with other Austronesian languages, is K. Therefore the author does not capitalize the second letter of a word which is proper noun or place name.

12.2.1 College of Agriculture and Mechanic Arts (1907–1911), College of Hawai‘i (1911–1920), a Land Grant College

The College of Agriculture and Mechanic Arts was established by Act 24, Legislature of the Territory of Hawai‘i, on Mar. 24, 1907), with the first classes held in 1908 in the Maertens House, which had been moved to a lot on Young Street, near Thomas Square[5]. An amendment to the Land Grant (Morrill) Act (by the US Congress, with a subsidy increase for A & M colleges) provided an inducement to the creation of this school in Honolulu, as well as the establishment of the Hawai‘i Agriculture Experiment Station (HAES), US Department of Agriculture (USDA), which was located on the Punchbowl slopes, at the end of Pensacola Street, where today Lincoln and Stevenson Schools are now located. The first faculty members were:

- Willis T. Pope, BS, Acting Dean (interim college head), Professor of Botany and Horticulture (on leave from the Territorial Normal School[6] (TNS), where he was Vice-Principal), 1907–1908; Horticulturist, 1921–1937
- Warren G. Ross, BSAgr, Instructor in Agronomy and Botany. 1908–1909 (who apparently joined the Pennsylvania Department of Agriculture in 1910)
- Vaughan MacCaughey, BSA, (Assistant Professor, first year) Professor of Botany and Horticulture, 1910–1919 (from the TNS staff in 1910; in 1919[7] he became Superintendent of Instruction, Territory of Hawai‘i)
- Joseph F. C. Rock, Botanist (1911–1920), Professor of Systematic Botany (1919–1920; also with the Office of Foreign Seed and Plant Introduction, USDA)

[5] This site has historical significance for the Hawaiian Kingdom, since this is where the ceremony restoring the Hawaiian Kingdom by Admiral Richard Thomas, to King Kamehameha III (Kauikeapiuli) took place on July 31, 1843. This ended the illegal seizure by Lord George Paulet and his warship *HMS Carysfort* 5 months earlier (Feb. 25). Kauikeapiuli’s adviser (Gerritt Judd) sent a protest of this action to Queen Victoria, who delegated Admiral Thomas to investigate and resolve the situation. The British flag was lowered and the Hawaiian flag raised. The crowd then reassembled at Kawaiaha‘o Church, where the King proclaimed, *Ua mau ke ea o ka ‘āina i ka pono* (the life of the land is perpetuated in righteousness, which became the motto of the Kingdom, and subsequently the Territory, and State). July 31 was celebrated as a national holiday, *Lā Ho‘iho‘i Ea* (Remembrance Day).

[6] In 1931, the Territorial Normal School merged with the university to become Teachers College (now the College of Education).

[7] After World War I, Central Grammar School (which is also a historic site, since it was the location of Princess Ruth Ke‘elikolani’s mansion, Keoua) was designated an experimental school for those who could speak “correct” English. In 1920, the US Bureau of Education completed a study of the Hawai‘i school system, and initially recommended grouping of students according to their ability to use English. That same year, 400 middle-class Caucasians who were unable to afford the tuition of Punahou School petitioned the Commissioners of Public Instruction to expand the trial program. Superintendent MacCaughey endorsed this idea, resulting in the establishment of the “English Standard Schools” system in 1924. This was continued until it was phased out, with the 1960 graduating class of Theodore Roosevelt High School (opened in 1930 at the Normal School site until the present building was completed in 1932, with the first graduating class in 1933) (Tamura 1994).

The first courses were taught by Pope with the theme: "to foster and propagate teaching and investigations that pertain to agriculture in the tropics" (applied science), and "in accordance…with the environment…the College should engage in all lines of research and investigation that will promote those lines of instruction…" (pure science). There were three courses in botany, and three in zoology. The course description for Botany 1 includes the statement that "an endeavor is made to acquaint the student with the economic significance of plants studied, with references to agriculture."

MacCaughey's objects (MacCaughey 1911) were to meld the applied science with the pure, emphasizing the unique flora of Hawai'i, the Hawaiian prehistory agriculture, and adapting local conditions for economic fruits. His report (MacCaughey 1911) stated:

- "The life and customs of the ancient Hawaiian is to the botanist a fruitful field for study."
- "There is not only this rich abundance of indigenous plant life, but also a bewildering array of introduced plants."
- "The Hawaiian…had a minute and exact knowledge of the varieties of food crops…and their cultural requirements. Much of this old knowledge could be profitably revived."

Although a separate ethnobotany course was not established until 1942, its concepts were incorporated in the botany courses.

Rock brought over his herbarium from the Board of Agriculture and Forestry on an indefinite loan basis upon the construction of the first building (Hawai'i Hall) on the Mānoa campus in 1912. The herbarium was transferred in 1920 under a reciprocity agreement (libraries, laboratories, and collections) and Territorial legislation to the Bernice Pauahi Bishop Museum. The herbarium was reestablished later to house teaching and research collections, and was named in honor of its founder. Rock obtained patrons to fund and publish his books, *The Indigenous Trees of the Hawaiian Islands* in 1913, which included botanical descriptions, black and white photographs, and a narrative of Hawaiian uses; and *The Ornamental Trees of Hawai'i* in 1917. He also sought to develop a botanical garden in the campus, and not only headed the College's committee, but was also responsible for bringing in both native and exotic plants (Chock 1963, 2013).

12.2.2 University of Hawai'i (1920-)

The movement to expand the college into a university and to offer graduate programs was spearheaded by a parent[8] who wanted his 11 children to have the opportunity to have an affordable higher education with a broader curriculum. Senate

[8] William K. F. Yap, Assistant Cashier, Bank of Hawai'i, who was the first to overcome the "glass ceiling" of large-scale business. He sought the help of the College's President and Board of Regents Chairman, and circulated a petition of 438 signatories of different ethnic groups and professions; however, seven of his best friends who were influential were not in accord with his request.

Bill 76 was passed and signed into law on April 30, 1919, effective July 1, 1920. Three of his children were students when the first semester began. Two colleges were formed in the new university: Applied Science (including agriculture, sugar technology, home economics, and engineering), and Arts and Sciences. There were two faculty members in the university's first decade who were involved in documenting the uses of plants:

- Otto Degener, Instructor of Botany, 1925–1927; (Naturalist, Hawai'i National Park, 1929–1930; Collaborator in Hawaiian Botany, New York Botanical Garden, 1935–1988) who published in 1930, the *Illustrated Guide to the More Common or Noteworthy Ferns and Flowering Plants of Hawai'i National Park: with descriptions of ancient Hawaiian customs and an introduction to the geologic history of the islands*
- Harold St. John, 1929–1958, Senior Professor of Botany and (many times) Department Chair (Gerritt Parmile Wilder Chair of Botany, 1950–1958, the first UH endowed Chair)

The Botany classes were taught in the first Mānoa campus building, Hawai'i Hall; moved in 1929 to the Biological Sciences Building, in what is now known as the "old quadrangle," which was subsequently named Dean[9] Hall. In 1962, the Zoology Department (now known as the Biology Department) moved to Edmondson Hall[10], and in 1971, with partial funding from the National Science Foundation (NSF), the Botany Department (College of Arts and Sciences) and the plant sciences faculty, laboratories, and facilities of the College of Tropical Agriculture and Human Resources (CTAHR) moved into the St. John Plant[11] Science Laboratory which was dedicated on Nov. 29, 1971. Dean Hall housed what was then called the General Science Department (now part of the biology course offerings) and the Archaeology Laboratory (Kamins and Porter 1998; Kobayashi 1983).

12.2.2.1 Botany 105

Botany 105, known originally as *Economic Plants of Hawai'i and the Pacific*[12], was first offered in 1942 by Professor Harold St. John. He spent about one-third of the

[9] Dean Hall was named in honor of Arthur L. Dean, second president of the College of Hawai'i, 1914–1927.

[10] A third floor electrical fire on Oct. 21, 2007 caused a water pipe to burst, extinguishing the fire, but flooded the building. Some of the faculty returned to Dean Hall. Groundbreaking ceremonies for a complete renovation of Edmondson Hall were held on Feb. 28, 2012, and completed in August 2013.

[11] The Plant Science Laboratory Building, dedicated on Nov. 29, 1971, is named in honor of Senior Professor Emeritus St. John (1892–1991). He was extremely pleased at this accolade, since buildings named for individuals are usually bestowed upon generous donors or deceased persons (conversation with his daughters, Mary St. John Zemach and Martha St. John Martin on May 5, 2013 at the 65th reunion of the 1948 class, Roosevelt High School, Honolulu).

[12] The course description was: "The cultivated and wild plants used in ancient and in modern times by the Hawaiians and Polynesians. Nature of these economic plants and their use for food, drink, dye, medicine, and utensils." It was offered in the first and second semesters for two credits. It was

class time lecturing on coconut. The course name has had a number of name and course changes:

- 1950 to Economic Plants of Hawai‘i
- 1954 back to the original title, Economic Plants of Hawai‘i and the Pacific
- 1958 Economic Plants of Hawai‘i
  - 1958–1960 instructor, Irwin E. Lane
  - 1961–1963 instructor: Al Keali‘i Chock, who changed the plant emphasis to taro, since it constituted 60–70 % of the Hawaiian diet and had an important role in the origin of people
- 1964 to *Ethnobotany,* with the number of credit hours increased from two to three semester hours
  - 1964–1967 and subsequent summers, instructor: Al Keali’i Chock
  - 1968–1974, instructor: Beatrice H. Krauss[13]
  - 1975–1995, instructor: Isabella Aiona Abbott[14], who in 1988 changed the course to two weekly lecture sessions, with a Friday morning demonstration and exhibits (come in anytime)
  - 1996–2004: instructor, Will C. McClatchey[15]
- 2005, to *Introductory Ethnobotany,* with the course format changed to ethnobotanical principles and subjects, with Hawaiian and Pacific plants as examples. The course was altered to video e-lectures and one weekly recitation-discussion class meeting, and a separate one credit laboratory (Bot 105L) was offered. The instructors were: Will C. McClatchey (2005–2010), Tamara Ticktin (2005), and Al Keali‘i Chock (2007–2008; honors section, 2011 to present). The course also was designated from 2006–2012 as a course meeting general education requirements[16] as a Global and Multicultural Perspectives in Group C (FGC). 2011 two weekly lectures and small laboratory sections, supplemented with a few video e-lectures (and discontinuance of the laboratories): instructors—Mark Merlin (in 2011), Anthony Amend (from 2012 to the present). The FGC designation was renewed[17], effective spring 2014

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not listed in the course catalogue in 1944–1945, when Dr. St. John was on leave. An interesting note is that Isabella Aiona Abbott was a teaching assistant for General Botany, Botany 100, that year.

[13] Bea graduated from UH in 1926 and was employed as a Plant Physiologist by the Pineapple Research Institute (PRI), which was located on the UH campus. She was the daughter of Frederick Krauss, Professor of Agriculture, and for whom Krauss Hall is named. The Hawaiian ethnobotany garden at the Harold L. Lyon Arboretum is named in her honor.

[14] Wilder Professor Emerita of Botany; Distinguished Economic Botanist, 2001.

[15] Now Vice President of Research, Botanical Research Institute of Texas (BRIT); Distinguished Economic Botanist, 2013.

[16] To satisfy bachelor degree requirements, students must take a total of six credits, and the courses must come from two different groups (A, B, C). These courses provide “thematic treatments of global processers and cross-cultural interactions from a variety of different perspectives. Students will gain a sense of human development from prehistory to modern times through consideration of narratives and artifacts from diverse cultures. At least one component of each of these courses will involve the indigenous cultures of Hawai‘i, the Pacific, or Asia.” In 2010, there were only five courses in groups A and C, and eight in group B.

[17] Anthony Amend spearheaded the documentation preparation.

Other ethnobotany courses taught between 1952 and 1961 included:

- Botany 110. *Plants and Man* (1952–1961; two credit, spring semester in alternate years) instructors: E. J. Britten; (in 1953), G. Girolami (in 1955), and I. E. Lane (in 1958). Course topics: The influence of a dozen important plants upon man and man upon plants; the development of such plants as corn, wheat, rice, cotton, etc.; the story of how plants have affected civilization
- Botany 262. *Structure of Economic Plants* (1952–1958; three credits, spring semester, alternate years), instructors: E. J. Britten (in 1953), G. Girolami (in 1955). Course topics: A study of the anatomy of the important field and garden crop plants representative of Hawaiian agriculture. One lecture and two laboratory periods. Prerequisite: Botany 100

In our *Introductory Ethnobotany* course (Botany 105) at the UHM, the use and application of available community resources to teach past, present, and future connections to plants by people, has evolved over a period of several decades. A half century ago, guided tours (with extra credit for attendance) to the Bernice Pauahi Bishop Museum (BISH) were conducted on two separate weekend days (to provide maximum attendance and to ensure smaller groups) with a handout listing the exhibit highlights, to a decade ago when faculty members were present as resource persons for a weekend period of 2 h ours (Bishop Museum 1915). A few years ago, to implement student-driven learning (as part of the AAAS *Vision and Change* program) which was elucidated for ethnobotany (McClatchey et al 2013) the student excursions became completely independent, with the completion of work sheets ("fill in the blanks"), and attaching a receipt to verify the venue visit. It was suggested that the students plan to spend a minimum of 2 hours at the venue. For those if they wanted to learn more about Polynesian voyaging and exploration, a 45-min. Bishop Museum Planetarium show, *Explorers of Polynesia* (which shows the sky chart from Hawaiʻi to Tahiti), was presented. The visit to the museum became as one of three student field trips, each worth five points in the final grade. The other two were to a botanical garden and a maritime history museum, to enable students to view additional collections to see cultural and historical connections with the plant world (Chock 2013).

Examples of venues in Honolulu, Hawaiʻi, which have been used as community resources, are described below. The work sheets, which are periodically revised, may be found on the Botany 105 website (https://sites.google.com/site/introductoryethnobotany/). They include brief information about the community resource(s): the address, phone number, opening times and dates, public transportation information, and the facility's website. Examples of questions included on the work sheets are found in italics in the venue's description in Sect. 12.3.1.2 of this chapter. Brief information is also provided about other places which we visited in this century in North America, Europe, and Asia.

12.2.2.2 Ethnobotany Major

Will C. McClatchey expanded the ethnobotany course offerings at UHM and the Ethnobotany Track for a B.S. in Ethnobotany, which was approved by the University of Hawaii's Board of Regents on July 18, 2005, to be effective the spring semester of 2006 initially for a 5-year period, and is now a regular program. This was the first ethnobotany degree program established in the USA. It is a multidisciplinary program (theoretical and applied research aspects) to include botany, anthropology, geography, Hawaiian studies, and biology. McClatchey was the Track Adviser, and David Reedy was the Track Coordinator. Since 2010, Tamara Ticktin has been the Track Adviser.

The Ethnobotany Track course offerings for the twenty-first century were taught mainly by McClatchey, Ticktin, and Kim Bridges[18], and the number of credit hours, included:

- Botany 440: Advanced Ethnobotany (3 credits)
- Botany 442: Medical Ethnobotany (3)
- Botany 446: Hawaiian Ethnobotany (3)
- Botany 448: Cognitive Ethnobotany (3)
- Botany 449: Ethnobotany Practicum (varied)
- Botany 498: Mekong Ethnobotany (3)
- Botany 640: Quantitative Ethnobotany (3)
- Botany 644: Ethnoecological Methods (3)

12.3 Use of Local Resources for Student-Driven Learning

12.3.1 Historical Collections

Most US counties have a historical society, and many organizations have gathered materials to preserve the heritage of the people who settled in that particular area. These organizations usually have an informal beginning, sometimes as a result of a social gathering of like-minded people.

For example, in Hawai‘i, a number of prominent and influential Honolulu citizens met in January 1892 to organize the *Hawaiian Historical Society* (HHS) with the purpose of "preserving historical materials relating to Hawai‘i and to publishing scholarly research on Hawaiian history. In subsequent years the society broadened to include the Pacific region and Hawaii's role within it." The HHS is an excellent example of the evolution of a historical group which first held ad hoc meetings, and then found a place to house their documents in an existing, private library (Honolulu Library and Reading Room Association[19], founded in 1879) from 1892 to 1915. Andrew Carnegie donated money to build the new Library of Hawai‘i building, and

[18] Retired in 2010, and was the prime mover of the *Open Science Network in Ethnobiology,* which was subsequently funded by NSF.

[19] To "provide a reading room for mechanics where they could spend an evening away from the allurements of saloons." King David, Kalākaua, Queen Kapi‘olani, Queen Emma, and Princess Bernice Pauahi, all donated personal collections, books, and other objects to this association.

additional funds were appropriated by the Legislature of the Territory of Hawai‘i. This cooperative agreement continued until 1950, when a building to house the HHS, Hawaiian Mission Children’s Society[20], and the Hawaiian Evangelical Association[21] archives. Today this organization has a small book store which sells Hawaiian history books at a discount to members, a library and archives, quarterly meetings featuring a lecture on a timely topic, and an annual publication on various researched aspects of Hawaiian history (Hawaii State Public Library System 2013; Hawaiian Historical Society 2013; Maxfield 2001).

While this is the major historical organization in Hawai‘i, there are many others, often devoted to a particular island (e.g., Kaua‘i Historical Society[22] and Kaua‘i Museum[23]), region (e.g., Kona Historical Society on the island of Hawai‘i, Koke‘e Natural History Museum), or ethnic group (e.g., Hawaiian Mission Children’s Society, United Chinese Society, Japanese Cultural Center of Hawai‘i, Hawai‘i Okinawa Center, Portuguese Hawaiian Genealogical Society). Some of these affiliates have museums that can be visited, while others have websites that provide useful information (Kaua’i Historical Society 2013; Mission Houses Museum 2013).

A large number of these historical societies in the USA invariably have a collection of various materials, accumulated by the so-called “first” settlers (usually people of European descent). These collections are first housed in residences, and then usually in conjunction with an already existing institution, such as a library, school, or church. Eventually, sufficient funds are raised to house it in a separate room or building. Today many First Peoples (the Native American tribes) have created or are in the process of constructing permanent buildings to house their articles. Some are large, like the Mashantucket Pequot Museum in Connecticut, between the large metropolitan areas of New York City and Boston, which was financed from the proceeds of the casino which the tribe built, while others are small, and more recently constructed.

In Europe and Asia there are many prehistoric collections, and many local, regional, and national museums. In many cases, it is a story of one group coming into an area and dominating the culture, and very often seeking to impose their beliefs and habits upon others, and sometimes to obliterate the host or conquered culture since the conquerors frequently believed that their civilization was superior, and

[20] A nonprofit educational institution which operates the Hawaiian Mission Houses Historic Site and Archives. The documents and artifacts represent the “missionary period” (1820–1863) and interprets the social history of Hawai‘i in the nineteenth century from the viewpoint of the missionaries of the American Board of Commissioners for Foreign Missions (ABCFM), founded in 1810 by Congregationalists, Presbyterians, Dutch Reformed, and other denominations.

[21] The Hawaiian Evangelical Association was founded in June 1863 when the ABCFM ended its work, leaving it to this organization, but remained partially under the control of the ABCFM in Boston. It is now the Hawai‘i Conference of the United Church of Christ.

[22] Established in 1914, and housed in the Historic County Museum 4396 Rice St. Suite 101, Līhu‘e http://kauaihistoricalsociety.org/. This organization has a collection of photographs, documents, maps, and personal papers from local families and organizations; helped to preserve many prehistoric sites, and establish the Koke‘e Natural History Museum (1953, Hui o Laka, http://www.kokee.org/) in Koke‘e State Park, and the Kaua’i Museum (1960), 4428 Rice St., Līhu‘e.

[23] The Kaua’i Museum now has a separate membership (http://www.kauaimuseum.org/).

the tribes they conquered were "savages." Two millennia ago the Roman Empire was dominant for many centuries, from England to Africa, and from Spain to Syria. One-fourth of the world was ruled by the Roman conquerors, and many remnants of the structures they built still remain (e.g., the Roman baths in Bath, England). They overcame and superseded the prehistoric tribes which were there earlier. If the locals adhered to the Roman laws, they were frequently allowed to keep some of their local customs and religious practices. This has followed even today, with the contemporary "Roman Empire," the Roman Catholic Church, which permits many of its adherents to continue some of their local practices. Unfortunately in the nineteenth century, many of the European colonial powers got together to "divide the world," with no concept whatsoever of tribal, ethnic, or religious divisions. This led to the formation of new countries which gained independence in the twentieth century; with artificial national boundaries, resulting in turn, led to bloodshed in many instances today, throughout the world.

These various forms of historical collections should not be overlooked in ethnobotanical instruction and research:

- *Historical documents* which may be scanned and recorded on computer servers (if they are not, they should be!). This is particularly true of microfilm or microfiche (the older papers are usually on bond paper, which has cloth fibers and generally are of better quality than current stationary which is made from wood pulp)
- *Voice recordings* (usually in a form (wax recordings, tapes, etc.) which deteriorates after time, so efforts need to be made to rerecord the materials in a more permanent format) of speeches, special occasions, interviews;
- *Photographs* (many of the old photographs used 8×10 glass plates as the negative, and many prints are of superb quality)
- *Clothing* (a number of museums have the clothing displayed on mannequins)
- *Tools,* and many other articles

Doing this type of examination may take our students back in time, from the twenty-first century to the twentieth or even further back! The students of today are fortunately equipped with smart phones, tablets, and other electronic devices which can facilitate such study and research.

12.3.1.1 History or Natural History Museums

Historical museums vary in the breadth and scope of their collections, depending largely on their funding sources and research capabilities. Some will charge an entrance fee; many have annual memberships in a support organization, while other only ask for donations. These institutions are usually supported by a nonprofit organization and have gift shops of articles and books. Most of these locations have various collections of documents, artifacts, and other objects, exhibited in a wide range of forms. Some of these venues are huge, while others are large, which have the dual purpose of education and a source of income. They invariably have active research staffs to collect and document natural and human history, safeguard the collections for the future, and share that information by permanent exhibits. Today, most of them try to tell the story from the beginning of the environment, to its effects by human cultures and the results of globalization. Most have an educational program that provides information through lectures and guided visits for school classes of various ages.

Natural history collections and exhibits may include botanical examples, specimens, or articles of plant origin. Zoological exhibits may consist of stuffed animals, birds, dried insects, etc. Geological ones include rocks or information about strata. While anthropological or ethnological items may consist of tools, clothing, housing, transportation, etc. One should try to weave together the interrelationships of all of these objects. Some example of large natural history museums include:

- *Smithsonian Institution* (Washington, D.C., and New York, NY) was founded in 1846 "for the increase and diffusion of knowledge," and states that it is the largest museum and research complex in the world, encompassing 19 museums[24] and galleries,[25] and the National Zoological Park. It serves as the US national museum, with many research centers. Admission is free, and funding comes from the institution's endowment, private and corporate contributions, federal government budget, membership dues, and other sources (Smithsonian Institution 2013).
- *Mashantucket Pequot Museum and Research Center* (Mashantucket, CT) opened its doors on Aug. 11, 1998, with a 308,000 square foot complex, with permanent exhibits featuring dioramas from the Ice Age to the arrival of the first peoples; the climate, changing environment, a Pequot Village, the arrival of Europeans and prelude to war, the Pequot war, life on the reservation, and the tribe today), classrooms, research laboratories, auditorium, museum shop, plant garden, laboratories, and library archives. The museum is funded by admission fees, membership dues, and income from the tribe's casino (Mashantucket Pequot Museum and Research Center 2013).
- *Royal British Columbia Museum* (Victoria, BC, Canada) has traveling and permanent exhibits. The latter include galleries of natural history, First Peoples, and modern history; n BC archives, and a native plant garden. The museum was founded in 1886, the archives in 1894, and they were merged in 2003, to become BC's provincial museum and archives.
- *Vietnam Historical Museum* (Ho Chi Minh City [Saigon] Vietnam) was established on Aug. 23, 1979, from the acquisition and restoration of the National Museum Vietnamese prehistory, Hung Vong Time or Metal Era, Struggle for Independence, feudal Era, Champua Culture (influence from India), Chinese colonization (Ming dynasty), uprising, civil war, French colonization, and independence. Some of the plants in the garden were labeled (Vietnam Historical Museuim 2013).

[24] In Washington, DC: African American History and Culture Museum,Air and Space Museum (Steven F. Udvar-Hazy Center in Chantilly VA), American History Museum, American Indian Museum, Anacostia Community Museum, Arts and Industries Building, Natural History Museum, Postal Museum, and Smithsonian Institution Building (the Castle).

[25] In New York City: American Indian Museum Heve Center, and Cooper-Hewitt, National Design Museum, African Art Museum, Freer Gallery of Art, Hirshhorn Museum and Sculpture Garden, Portrait Gallery, Renwick Gallery, and Sackler Gallery.

Other museums are medium-sized or smaller. The use of a search engine with the name of the location plus historical museum, applicable subjects, such as historical society, museum, history museum, etc. (or vice versa) generally provides the beginning of a treasure trove. Many are also listed in visitor guides, American Automobile Association tour books, and similar publications. Exploring the venue will determine its suitability for student-driven learning. Many of the objects displayed, if analyzed further, may indicate their origins in plants. Here are some examples of such museums:

- *Navajo Nation Museum* (Window Rock, AZ) opened in 1961, and the exhibits portray the events in prehistory: the Navajo way of life, the cornfield (sacred place), ceremonial basket (symbol of growth, prosperity, and knowledge), and rules to ensure harmony and balance for the mental, physical, and spiritual health.
- *Frostburg Museum* (Frostburg, MD). The *Society of Economic Botany* (SEB) held its 53rd Meeting at Frostburg State University (FSU), Frostburg, Maryland in 2012. Prior to the gathering we went to the city's historical museum to verify that this type of activity is present. The museum boasts that it is a "Showcase of Local History and Regional Art." Its mission is "to acquire, document, preserve, and display artifacts and other items related to the history of Frostburg, Maryland, its people and its environs, and to provide access, information, and education to those interested in the research and study of our area." Not only does the museum house historical artifacts, it is itself housed in a historical building, the Hill Street school building, constructed in 1899. One of the collections on the first floor is obviously related to botany, a collection of woods by one of FSU's students. This could be a starter, to document uses for one or more species of this collection. There is a reconstructed exhibit of a coal mine, and another student project could be based on the relationship and origin of plants to a fossil fuel. The second floor houses historical objects, including clothing, which could be expanded to document the relationship of plaints to the objects exhibited.
- *Animas Museum* (Durango, CO) is another historical organization which has its exhibits in an old school building constructed in 1904 and owned by the LaPlata County Historical Society. Since it is in an old school building, it has a restored 1905 classroom. It includes a Native American Gallery, with selections of potter, basketry, beadwork, and weavings from the Four Corners region, as well as information about the early white settlers in the area: clothing, tools, letters, and other documents. Coal (just like Frostburg, MD) in the area provided the fuel for mineral processing. On a personal note, I discovered in this museum that my wife's great-grandfather came through here in 1878 to live and successfully mine in Silverton for 25 years, some 50 miles north, across three mountain passes! The nearby Fort Lewis College, a land grant institution, has many documents and newspapers preserved on microfilm.

12.3.1.2 Bernice Pauahi Bishop Museum

An example of a natural history museum used in the UHM Botany curriculum is the *Bernice Pauahi Bishop Museum,* first founded by Charles Reed Bishop as a memorial to his wife, Bernice Pauahi (who died on Oct. 16, 1884, was the last descendent of the Kamehamehas; she left her estate for Hawaiian education: the Kamehameha Schools), to contain and display her heirlooms and collections. The initial expansion and construction took about a decade, with the building of the entrance hall in 1889, with three exhibition rooms; today it is Kahili Room on the left, and on the right, the vestibule (now known as the J. M. Long Gallery) containing different, special topical exhibits, such as (Bishop Museum 1915):

- *ʻike Loloa: a Long Insightful Journey* (May 17–Oct. 7, 2013), which celebrates the artistry, mastery, and the beauty of Hawaiian visual arts community
- *Niʻihau shell exhibit* (Oct. 26, 2013– Jan. 27, 2014) from a private collection which features the ocean, origins, living traditions, manufacturing history, and the master craftsmen

The Polynesian Hall was built in 1894, to provide more exhibition space and research facilities for the increasing collections; was completely renovated in 2012–2013, and renamed the Pacific Hall, and explores the origin of the Pacific Islanders, migrations and settlement of the Pacific, and culture and values of the Pacific peoples. The exhibition will display some of the artifacts of the closed (2009) Hawaiʻi Maritime Museum[26], so that the objectives and questions (the answers are derived by careful examination of the exhibits) below, developed several years ago by Will C. McClatchey, were in part reused for the Pacific Hall exhibits when it opened in the Fall 2013:

Objectives of the visit are conservation of Polynesian voyaging knowledge, conservation of plant knowledge, conservation of canoe construction knowledge, conservation of navigation knowledge (Polynesian Voyaging Society 2013).

- What plants are used for the different items?
- How are these plants made into useful articles?
- How are the different parts used?
- How are canoes sailed efficiently?
- How are sailing technologies learned?
- What are the different navigational aids available to a traditional navigator?
- Describe one of the canoes exhibited (culture of origin, size and probable use, plant materials (other than wood)).

Will McClatchey and I developed the following questions concerning the Hawaiian Hall (first floor) exhibit “*Kai ʻākea*: the Hawaiian gods, legends, beliefs, and the world of pre-contact Hawaiʻi” in response to feedback from our teaching assistant, Katie Kamelamela, following the renovation of the Hall:

[26] The Polynesian Voyaging Society (www.hokulea.org) was founded in 1973 for scientific inquiry of the prehistoric voyages to discover the Pacific islands. A replica of an ancient double-hulled canoe, the Hōkūleʻa (star of gladness) was built and sailed to Tahiti in 1976, using prehistory navigation methods, without instruments. Since that time, more voyages have been made throughout the Pacific, and they are now in the midst of a worldwide voyage.

Objectives of this visit are to show articles which were made in prehistoric Hawai‘i,and their relationships to the plant world, and its role and importance in the daily life of the Hawaiians.

Identify two plant (common and scientific names[27]) kinolau[28] for each of the four major Hawaiian gods:

- *Ku* (protector and provider)
- *Kāne* (source of water and, life)
- *Lono* (deliverer of water, peace, and fertility)
- *Kanaloa* (ocean)

On the Hawaiian Hall (second floor) exhibit "*Wao Kanaka,* where people live and work, focusing on the importance of the daily life," we used the following assignments:

Study an exhibit with Hawaiian material culture (example: cordage, fishing/farming implements, adornment, weapons, etc.). Watching available videos or reviewing historical photographs in the exhibition area may facilitate understanding of the items within the cases. Enhanced information is provided for: "olonā, cordage, fishing, gourds, kapa". Identify two (2) objects and report the following for each:

- Exhibit category
- Name of cultural object
- Specific use of the item
- Plant or animal parts (provide the common and scientific names)
- Abundance of the object on display
- Object used by (men, women, children, chiefs, commoners, etc.)

Locate exhibits of Hawaiian containers and clothing preparation tools:

- Some containers have evidence of repairs. Why would people repair containers rather than make new ones?
- Identify four (4) different types of containers: function of the container, plants used to make the container, and other plants/tools used in processing the container
- Identify four (total of six) methods used to mend or repair some containers

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[27] Previously, students perused books to find the scientific name; in the technological world of the twenty-first century, the use of a search engine will at the minimum, expose the student to more information about the plant.

[28] *Kinolau* is defined in the Hawaiian Dictionary as "many forms taken by a supernatural body." The Hawaiian religion consisted of many gods; of which were four major gods, with other gods at a lower hierarchy, such as Pele (goddess of fire), Laka (goddess of hula), Pōli‘ahu (snow goddess of Mauna Kea), Kamapua‘a (sweet potato and pig), Hi‘iaka (younger sister of Pele); there were also gods for occupation/profession, such as fishing, farming, etc., plus family gods. Lest this appear to be overwhelming, the average person recognized the different levels, but unlike other religions, did not have to personally encompass all of them. For most, it was usually either a profession or family god.

Fig. 12.1 A feather cloak would appear to have no connection with plants. However, plant materials were important from the start. The bird catcher would wear a cloak made from kī (*Cordyline fruticosa*) leaves to serve as a camouflage in the forest. He would wait patiently in the dense forest with a stick that was smeared with the sticky breadfruit (ʻulu, *Artocarpus altilis*) sap. When the endemic birds, now extinct, with tufts of *yellow* feathers(ʻōʻō, *Moho* spp. or mamo, *Drepanis pacifica*) landed on the stick, he would soothe the bird, remove the *yellow* feathers, then wash the birds feet with kukui (*Aleurites moluccana*) nut oil to remove the sticky glue and then release the bird. The fate of the ʻiʻiwi (*Vestiaria coccinea*) bird was not as fortunate, since the body was mostly covered with *red* feathers (the wings and tail were *black*); nothing was wasted, since the bird provided someone with a meal. The netting for the cloak was from the inner bark of olonā (*Touchardia latifolia*). This is known as the "Joy Cloak," because it was given to Capt. Joy of Boston, but eventually returned to HawaiʻI; it has triangular teeth or wings in the front, and *yellow* circles in the back. (Photo by Al Keali'i Chock)

- Musical instruments (instrument name, and the materials used (plant, animal, or mineral? Common and scientific names)

In the Richard T. Mamiya Science Adventure Center, we used these assignments:

Locate an exhibit that discusses the colonization of the Pacific Islands (Remote Oceania) and record the following information:

- Identify two transported animals (common name and scientific name)
- Identify six transported plants (common name and scientific name)

Other exhibit areas include: Hawaiian Hall (third floor) "*Wao Lani,* where the gods live, chiefs, and key moments in Hawaiian history"; Paki Hall, which con-

Fig. 12.2 Wooden bowls, most frequently carved from the wood of the indigenous kou (*Cordia dubcordata*), served as containers for poi, made from the cooked, pounded corm of taro (kalo, *Colocasia esculenta*), which is mixed with water and allowed to ferment. Unlike today, when broken things are tossed away, bowls that were cracked or broken were carefully patched using a wood patch and breadfruit glue or putty (sap mixed with soil). (Photo by Al Keali'i Chock)

tains the Hawai‘i Sports Hall of Fame, the library, archives, and education division; Konia Hall and Pauahi Hall, which house the researchers in the Science Division (botany, entomology, ichthyology, invertebrate zoology, malacology, vertebrate zoology, and Pacific Center for Molecular Diversity) and Cultural History Division (anthropology, cultural collections, library, and archives); Castle Memorial Building, with traveling and roving exhibits on the first (e.g., Life Through Time: Dinosaurs and Ice-Age Mammals, April 27–Sept. 15, 2013) and second floor, and the staff on the top floors; and Bowman Hālau Wa‘a, the canoe house. (see Figs. 12.1, and 12.2)

12.3.2 Newspapers

Newspapers were the webpages of yesteryear, albeit very localized with a much smaller, narrower audience. Sometimes they were printed on high quality paper. More often than not, they were published on wood pulp paper, which yellows and disintegrates with age. In many cases, they have been copied on to microfilm or microfiche, which makes reading them a tiresome, eye-wearing task. Fortunately, some of them have been preserved in a much more readable and searchable form. In the USA, the Library of Congress has a website known as *Chronicling America*; many newspapers have been put on OCR and may be viewed and searched. However, this is a job which is still “in progress.”

12.3.3 Botanical Gardens

Initially, the UHM botany instructors conducted tours of the Harold L. Lyon Arboretum, Foster Botanical Gardens[29]; and the UHM campus. Later, we encouraged student-based research, with the instructors available for consultation on site at certain times. Still later, we had the students conduct independent visits and attach the visit receipt to the completed work sheet, in order to determine their observation of garden plants. This program instituted the concept of student-driven learning. The following questions were developed originally by Tamara Ticktin, and required the students to provide both the common and scientific names for plants found in the gardens:

- Two trees that provide spices
- Two psychoactive plants
- Three important Polynesian crops
- One vine that provides a spice
- One vine that provides a flavoring
- Two culinary spices
- Two sources of sugar
- Plant used for dye from tropical America (Fig. 12.3)

12.3.4 Cultural, Ethnic, or Plant Activities

With the demise of the Hawai‘i Maritime Center, an additional activity was proposed, making use of Hawai‘i’s population, which consists largely of Asian and Pacific heritages. Unlike other population groups, Hawai‘i has the distinction of having every ethnic group as a minority.

There are, however, celebrations of European cultures, which in other parts of the USA may be the majority group. One activity which was widely publicized, and even advertised (paid advertisement) in the newspaper was, for the first weekend in April is the Annual (in 2013, it was the 32nd) Hawaiian Scottish Festival and Highland Games. Attendance at such events can show the relationships of a different ethnic group’s use of plants for food, beverage, clothing, dance, games, ritual, and other activities, and also the important role in which plants played in these different activities. Usually the first thought is food or beverage, but plants can be processed, resulting in many different products other than food, beverage, or medicine.

We employ the concept of student-driven learning (find an activity and report on it) when instructing students to participate in these events. These assignments

[29] Part of the Honolulu Botanical Gardens system of the City and County of Honolulu. Mary Foster bequeathed her property to the City and County. It was originally the estate of William Hillebrand, M.D., who was the first physician of the Queen’s Hospital, established by Queen Emma. Hillebrand recruited Chinese (1850s) and Portuguese (1875) laborers for the sugar plantations, and authored the *Flora of the Hawaiian Islands* (1888).

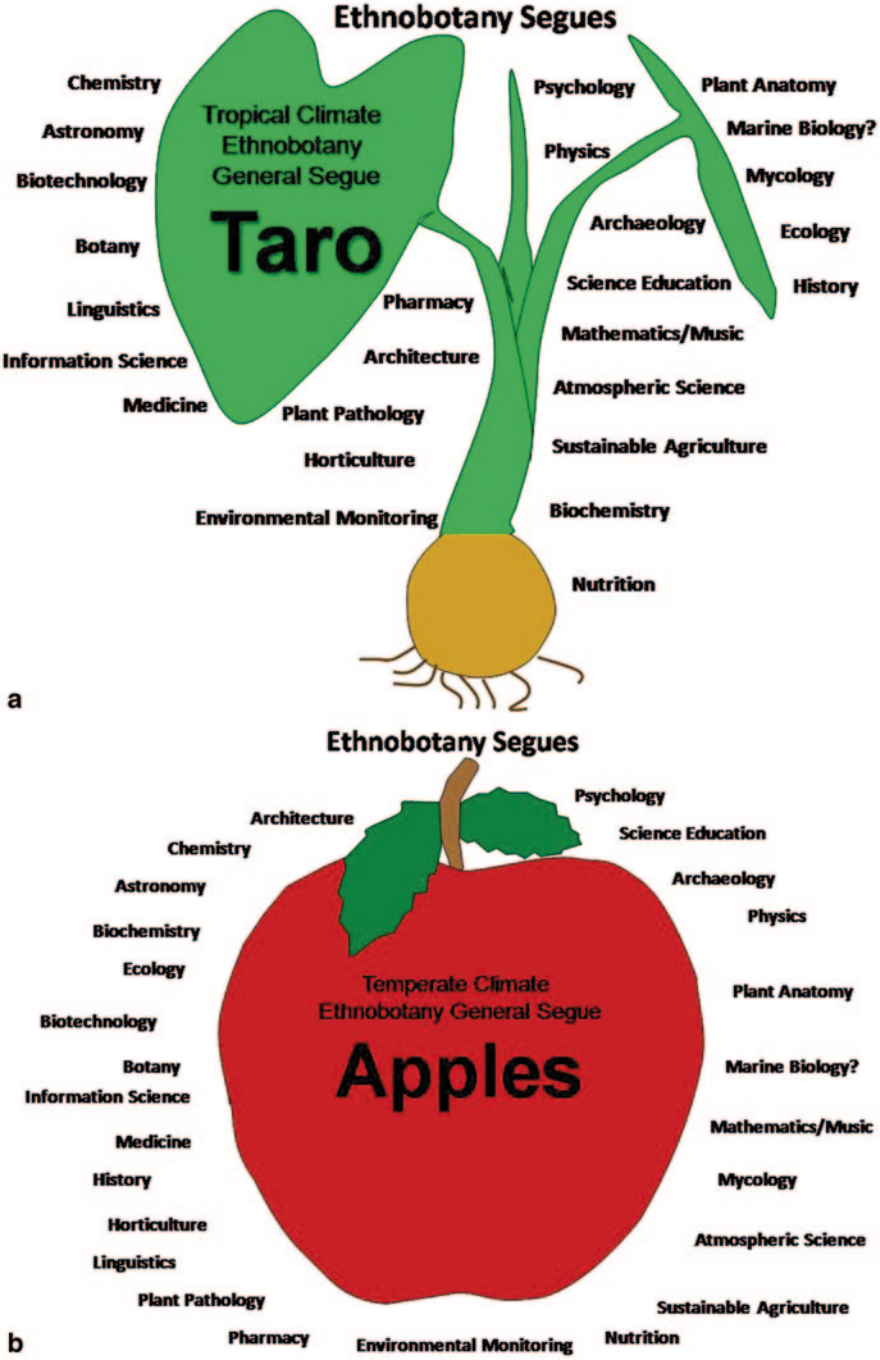

Fig. 12.3 Keystone plants: **a** taro for the tropics and **b** apple for the temperate zone. (Illustrated by Will C. McClatchey and David Reedy)

require advance research efforts, initiative, and ingenuity by the student (subject to instructor approval). Students are instructed to identify community sponsored events, activities, shows, exhibitions, or meals (noncommercial) with Asian, Pacific, or Hawaiian themes for this assignment. Here are the instructions and contents of the work sheets that we have used for these assignments:

- Pre-event research:
  - Find appropriate activity (instructor concurrence required)
    Name of culture or ethnic group
    Source of information about event
    Reference sources for background information

- Name, sponsoring organization, and date of event
- Describe (who, what, when, where, why, and how) the event's relationships to plants and people
- Origin of event (describe cultural affinities)

Examples of events chosen by the students have included:

- Special exhibition, program or lecture at gardens or museum.
- Special ethnic, food, or beverage festivals (Hawai‘i is fortunate to have many, periodic ethnic festivals, which usually take place in city or state parks, such as Thomas Square, Ala Moana Park, Kapi‘olani Park; the following is just a sample of what is available):
  - January 1: New Year observed by Japanese and many Southeast Asian groups,
  - January–February: Chinese New Year/Narcissus festival (depends on the lunar cycle),
  - February: Salsa festival (first weekend),
  - March: Cherry Blossom festival (depends upon the weather in Japan), Honolulu festival (Hawai‘i and Japan), Merrie Monarch Hula festival (the week after Easter, in Hilo),
  - April: Scots (first and second weekends),Samoan Fire Knife competition (at Polynesian Cultural Center), SPAM jam (in Waikīkī),
  - May: May Day is Lei Day (first), Wahiawa Pineapple festival, Book and Music festival (third weekend at City Hall),
  - June: Pan-Pacific Ho‘olaule‘a (first Friday), King Kamehameha Day (June 11),
  - July: Prince Lot Hula festival (third Saturday at Moanalua Gardens), ‘ukulele festival, Korean festival,
  - August: Greek Festival, Mango festival, 30th Slack Key Guitar, Made in Hawai‘i festival (at Blaisdell Arena),
  - September: food and wine festivals; Rice Month (this is a national event sponsored by the US Rice Federation), Okinawan festival (first weekend), Portuguese Festa, Aloha festivals,
  - October: Oktoberfest (in München it begins in September), Kava festival (second Saturday), Halloween (31st),
  - November: Coffee festival (first week, in Kona),
  - December: Festival of Lights (first Saturday), Christmas (25th),

- Exhibitions, art shows, performances
- The *Hō kū le' a,* the canoe replica of early Polynesian voyaging, was constructed by the Polynesian Voyaging Society. This vessel was launched in 1975 and made its maiden roundtrip voyage to Tahiti in 1976, and is currently embarking on a worldwide journey (Polynesian Voyaging Society 2013)
- Special work (restoration) programs: trail clearing, clearing of invasive species, fishpond restoration, etc.
- Programs sponsored by the Ethnobiological Society of the University of Hawaii. More recently a specific community resource has been designated for tis phase, with a visit to the Honolulu Chinatown. This venue today includes not only Chinese businesses, but also Vietnamese, Thai, Japanese, Filipino, Korean, and Caucasian merchants working harmoniously together to perpetuate their respective cultures (Nguyen et al. 2008). The students are asked to compare, contrast, and explore the different commodities, to include the different prices, and the original and current export origin. The students may not be cognizant of some of the produce.

12.4 Conclusion

Using community resources has a twofold benefit: it provides venues for students to explore that are nearby their place of learning, residence, or work, thus reducing transportation time; and it gives them, in many instances, a personal connection to some past activities which may relate to their family, friends, acquaintances, or groups. These neighborhood locations supply a better and closer understanding of the importance of plants in cultural and societal processes, and frequently stimulate students to continue to learn more (Chock et al. 2012; McClatchey et al. 2013).

A list of potential sites may be developed by using key words (e.g., gardens, history, museums, and plants) as the starting point. This may be done in the old way of "walking through the yellow pages" of printed telephone directories, or using Internet search engines (e.g., Google, Yahoo, AVG, Ask, etc.). Determining whether a venue is feasible or worthwhile will take more time, and a visit to the facility. This task may be undertaken by the instructor, or by a student (graduate or undergraduate) project, with observations and notes on the relevance of the facility to providing information about a group's connection with and relationship to plants, and if it will expand the student's knowledge of ethnobotany.

When an institution or organization is deemed to be an adjunct to learning, sets of questions as described above for a natural history museum (Sect. 12.3.1.2), botanical gardens (Sect. 12.3.3), or activity (Sect. 12.3.4), may be developed. Open ended or specific questions may be used, depending upon the level of the student and the type of the location. The examination and evaluation of historical documents (Sect. 12.3.1 above) is usually best assigned to more advanced students. Sometimes the compilation of these sources will provide new information or additional data, which may lead to publication in a peer-reviewed journal, or at least a preliminary posting on a website.

Most[30] of the students stated that the field trips were useful learning experiences and opportunities. They particularly enjoyed the hands-on experience with plants and plant products. Students have stated that the course and outside activities now made them more curious about the natural world.

The downside to independent student field trips is the procrastinator who postpones it to the last minute and does not successfully complete the assignment. For example, if they are using public transportation, students may forget that on weekends, the frequency of busses are on a weekend schedule, with longer intervals between busses, and because they have not budgeted their time, reach the facility just before closing time! Although the institution's website and operating hours are given on the work sheet, some students will go to the facility on the day that it is closed! The other problems are the students who go to the facility without the work sheet that has the assignment questions.

Some of the students elected to participate in work parties (for at least a half day) to restore or maintain pre-Hawaiian agricultural systems (e.g., lo‘i or taro terraces, fish ponds) or remove invasive species in selected forest ecosystems. These instances gave them a better appreciation of the difficulties and tribulations of those who created these elaborate systems. Many have continued to participate in these monthly work parties after the conclusion of the course, and have deemed their voluntary community service as being very beneficial.

Other locations that are used in advanced classes and in the introductory laboratory section could also be used in the introductory course to stimulate plant connections. This would include, for example, an examination of farmer markets, ethnic food stores, organic food sources, and supermarkets. The identity of the produce (fresh, frozen, or canned), its production origin, the original origin of the species make for interesting comparisons of how food supply has become more and more diverse with the expansion of globalization and world trade.

Look around—a learning resource may be in your backyard!

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Part IV
Teaching Through Field Experiences

Chapter 13
Learning in Paradise: The Role of Botanic Gardens in University Education

Bradley C. Bennett

Paradise—from the Greek parádeisos (παράδεισος), and ultimately from the Persian pairidaêza—enclosed spaces where plants grew.

13.1 Introduction

A garden means different things to different people, and the kinds of gardens run the alphabet from alpine to zoological gardens. The English word "garden" is derived from the Old High German *gart*—an enclosure, particularly an enclosure containing plants. Yard, orchard, and court are cognates. The term garden is also akin to the term paradise. For some, the garden is the yard surrounding a suburban dwelling. For others, the boundaries are less defined. Among rainforest dwellers, their term includes plantings around the house, cultivated field, and even the adjacent forest. Gardens, in the broadest sense, encompass a diverse array of plant collections (Fig. 13.1).

Botanic (or botanical) has a more specific meaning. Warren (1989, cited in Watson et al. 1993) defined a botanic garden as "a place set aside for the collection, cultivation, and study of plants, serving a variety of scientific, educational, and aesthetic purposes." Wyse Jackson (1999) offered a similar definition: "an institution holding documented collections of living plants for the purposes of scientific research, conservation, display and education." Of the thousands of gardens in the world (Figs. 13.2 and 13.3), few achieve all four objectives, and seldom are these objectives integrated or considered to be of equivalent importance.

While most would agree on the four primary roles of public display, research, education, and conservation, the latter recently has become a major focus of many botanical gardens (Ballantyne et al. 2008; Chen et al. 2009; Donaldson 2009). Botanic

B. C. Bennett (✉)
Department of Biological Sciences, Florida International University,
11200 S.W. 8th Street, Miami, FL 33199, USA
e-mail: bennett@fiu.edu

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Fig. 13.1 **a** Shuar home garden with pineapple (*Ananas comosus* (L.) Merr.), sweet potato (*Ipomoea batatas* (L.) Lam.), ginger (*Zingiber officinale* Roscoe), and cassava (*Manihot esculenta* Crantz). **b** Garden plaza in Xalapa, Mexico

gardens also offer unique opportunities for the study of ecological restoration (Hardwick et al. 2011), global climate change (Donaldson 2009; Primack and Miller-Rushing 2009), and even the relationship between humans and nature (Heyd 2006). Nonetheless, Watson et al. (1993) noted that the recurrent functions of botanic gardens were research and education and that those two functions differentiated botanic gardens from parks. The authors also questioned use of the moniker "botanic garden" by institutions not engaged in both education and research. Likewise, He and Chen (2012) cited education and research, along with ex situ conservation, as the major roles of botanical gardens. In this chapter, I focus on two of the objectives of botanical gardens—education and research, specifically at the undergraduate and graduate levels. I hope to make three points in this essay: (1) botanical education is crucial (and not merely for botanists), (2) gardens are integral components in comprehensive training, and (3) gardens are underutilized but invaluable resources.

13.1.1 Brief History of Botanic Gardens, Research, and Education

It may surprise many that botanic gardens and universities share a common heritage. The formation of the physic gardens, which often were associated with universities,

Fig. 13.2 a Luther Burbank Home and Garden, Santa Rosa, CA. **b** Coker Arboretum, University of North Carolina, Chapel Hill, NC. **c** The New York Botanical Garden, Bronx, NY. **d** Belfast Botanic Garden, Belfast, Ireland

began in the 1540s with the university gardens at Padua and Pisa. Subsequently, botanical inventories of the gardens, often compiled by people holding medical degrees, were published. Many of the compilers also travelled widely, adding exotic plants to the collections (Holmes 1906).

The modern European botanic garden has its roots in the medicinal plant gardens associated with the medical schools of Renaissance universities (Brockway 1979). Hill (1915) suggests that the establishment of gardens by university medical schools was "largely owing to the need of protecting the doctor and apothecaries against the drug sellers." Dr. Robert Morrison was the first professor of botany at Oxford University. Hill describes Morrison's inaugural lecture of September 2, 1679. "He translated himself to the Physic Garden where he read in the middle of it (with a table before him) on herbs and plants for five week space." Botany remained an important part of medical education for at least the next 200 years. The University of Glasgow established a joint professorship in botany and anatomy in 1718 (Olszewski 2011). The use of fresh plant material from associated physics gardens continued at least through the late 1880s. Isaac Bayley, University of Edinburgh, Professor of Botany (1888–1892), covered his lecture table with plants and flowers from the garden and the hothouse (Olszewski 2011).

The major botanical gardens in the USA also were established with university education in mind. Henry Shaw founded the Missouri Botanical Garden (MBG) in 1859. In 1885, Shaw established the Henry Shaw School of Botany at Washington

Fig. 13.3 a The Kampong, National Tropical Botanic Garden, Coconut Grove, FL. **b** Kanapaha Botanical Garden, Gainesville, FL. **c** Queen Sirikit Botanical Garden, Mae Rim, Thailand. **d** National Tropical Botanical Garden, Allerton Garden, Kalāheo, HI

University and created the Engelmann Professorship of Botany, which is held by the director of MBG (Rudolph 1991). More than a century ago, the synergistic relation between the two institutions was predicted to become a "leading center for research, experiment, and instruction in pure and applied botany" (Anonymous 1886). Today, MBG has achieved that goal and is one of the world's leaders in botanical education at the graduate level. Its graduate program has expanded to include other universities in addition to Washington University and graduates from its program span the globe. Walter Lewis (1972), a former MBG director, observed that the MBG consortium permitted students to study plants in "the heart of the living collections" and that the garden had become what it was intended to be—"the classroom and laboratory of the botanical community."

The New York Botanical Garden (NYBG), founded in 1891 (Britton 1915) launched its Graduate Studies Program with Columbia University in 1896 (Fig. 13.2c). This arrangement continued until the late 1960s (Lentz and Bellengi 1996) and like MBG, the NYBG graduate program now includes other universities. NYBG with its herbaria, library, museum, and laboratories, coupled with its Colombia University's Department of Botany partnership, created an entity that rivaled any botanical institution in the Old World (Hill 1915). Other major garden–university partnerships, including Arnold Arboretum/Harvard University, University Botanical Garden at Berkeley, and the Botanic Garden of the University of Pennsylvania, were established in response to the needs in teaching and research in botany (Hill 1915).

13.2 University Level Botanical Education and Botanical Gardens

13.2.1 Botanical Education Is Crucial

Crane et al. (2009) aver that "at no other point in history has research in botanic gardens and arboreta, been more important." Society is becoming ever more removed from both the experience of nature and knowledge of the natural world. Green plants are the dominant and the most salient elements of terrestrial ecosystems; yet, they mostly are neglected in both high school and university biology courses. Sundberg (2011) documented the decline of botany courses at universities throughout the USA. Woodland (2007) considers botanists to be the "dinosaurs of biology in the 21st century," as the number of botany students, botany classes, botany departments, and botanist's attendance at national meetings continues to diminish in North America. He also provides several suggestions for reversing or slowing the trend, including engaging students outside the laboratory and emphasizing the value of botanical gardens.

Sundberg et al. (2011) surveyed 1,500 academic faculty, graduate students, government employees, and nongovernmental organizations (NGOs). One of their conclusions was the "Critical need for botanically trained professionals." More than 90% of surveyed government employees indicated that their agencies lacked the botanical expertise to meet their current management or research needs. They also found that among the skills desired by employers were "Field skills, plant identification ability, and general botanical knowledge." All subjects aptly suited for botanical garden education programs.

13.2.2 Gardens Are Integral in Comprehensive Training

Botanic gardens are living laboratories. While a botanical library and herbarium can form the foundation of botanical education, they must be complemented by a garden (Anonymous 1886). The eminent ecologist Frederick Clements (1911) avowed that "beginning botany cannot be properly taught without adequate greenhouses, as well as gardens." He even argued for the replacement of textbooks and lectures with hands-on experiences with plants.

Botanic gardens are not substitutes for study in natural areas but should be viewed as complementary, and they offer several advantages to the latter. Among the advantages of botanical gardens are the following:

1. **Convenience and accessibility:** University/garden partnerships, especially when gardens are on or near campus, allow students and faculty to readily visit collections. Instruction time is limited and every hour driving to a field site means 1 hour less of study. Moreover, gardens are designed so that the plant collections are easily accessible.

2. **Diversity:** Some natural areas are species rich, especially those closer to the tropics, but few equal the species density of gardens. In most natural systems, a few species dominate the vegetation. In gardens, there is a greater equanimity where fewer individuals of a species per area equate to more total species.
3. **Global perspective:** In a temperate North American garden, students can see *Chusquea* from Chile, *Eupatorium* from Europe, and *Juniperus* from Japan. In a tropical garden, visitors might encounter *Brassavola* from Brazil, *Cola* from Cameroon, or *Veitchia* from Vanuatu. A few hours of strolling through a garden can be the equivalent of a circumnavigation of a global climate belt. Climate-controlled glasshouses can extend the tour to encompass even more of the world's diversity. Many forward thinking gardens now include local plants as well. For example, teaching plant taxonomy at Fairchild Tropical Botanic Garden (FTG) in Miami, permits students to examine species of Fabaceae from the Neotropics, Africa and Asia, Australia as well as southern Florida, in a single afternoon.
4. **Repeat visits:** Owing to their convenient locations and accessibility, students can return to a garden for additional study and review. It is much easier to learn plants when their names and origins are embossed on a metal tag. Serious students return to the gardens long after their final grade has been recorded.
5. **Aesthetics:** An underappreciated aspect of education is the aesthetics of the learning environment. Among the ways to improve learning is to create a physical environment that supports and encourages learning. Teaching about plants makes sense in a botanic garden owing, in part, to the accessibility of living material. Yet the garden environment is more than a source of pedagogic material. Gardens offer a respite from the normal learning environment that can foster concentration, eliminate distractions, and inspire students.
6. **Outdoor learning:** Learning about the outdoors is best accomplished while outdoors. Most people have a limited knowledge about the common organisms, especially the plants that surround them (e.g., Bebbington 2005). Students learn more effectively about living organisms when they encounter those organisms in the field (e.g., Bauerle and Park 2012; Scott et al. 2012; Taraban et al. 2004). Field components in courses allow student to integrate what they have learned in the classroom (Dillon et al. 2006). Moreover, field courses at the college level can enhance student interest and attention in environmental-focused humanities courses—including environmental history, philosophy, and literature (Alagona and Simon 2010).
7. **Human–nature relationship:** Much of the so-called natural world is a result of both ecological and evolutionary processes as well as the intervention of humans, whether intentional or not. Clark (1996) persuasively argues that the commonly used term "virgin forest" is meaningless. Even as early as 1500, most of the world's vegetation had been affected by some form of human activity. Increasing CO_2 levels during the past century have rendered the question moot. All of the world's forests have been affected (Vitousek 1994). During a recent visit to the Chocó Forests of Ecuador, I accompanied three of my indigenous Chachi colleagues on a 3-day trip to visit a waterfall that they considered to be sacred. The trip required a 5-h motorized canoe journey to the village of Loma

Fig. 13.4 a Chachi village Loma Linda, Ecuador. **b** Poling canoe up the Rio San Miguel. **c** Base camp in sacred Chachi forest. **d** Metate near trail of sacred forest

Linda, a 2-h trip in a smaller motorized canoe, followed by an hour of poling up the Rio San Miguel in an even smaller canoe. An 11-km hike took us to a base camp. The next morning, after a 2-h hike, we arrived at the waterfall (Fig. 13.4). The view was spectacular (Fig. 13.5). The forest was seldom visited by humans, and our trip was one of the fewer than a dozen that the Chachi had made in the last 100 years. The forest was replete with large trees, diverse epiphytes, and scores of flowering Gesneriaceae. Animal diversity rivaled that of the plants with three species of primates, a 5-m long boa, a 2-m long bushmaster, scores of collared peccaries, and fresh jaguar tracks. Despite the spectacular biodiversity, what impressed me most was a piece of rock. Near our path, we found a large metate, a carved stone used for grinding corn (Fig. 13.4d). Four of us could barely move it and a smaller one found nearby required at least two people to lift it. Why was this interesting? It revealed that the forest, which would have been termed "virgin" by many ecologists, had once been someone's cornfield.

Human impact on most of the world's vegetation is now widely accepted, ranging from enrichment planting, to protection when clearing field to intentionally planting along trails (Bennett 1992). Over several generations, such activity can significantly alter vegetation composition and structure. Perhaps then, we should consider the Chachi forest to be a kind of garden. David Fairchild (1838) wrote, "The World is My Garden" describing his adventures in plant collecting. One could accurately paraphrase Fairchild's book title as the "World is a Garden."

Fig. 13.5 a Old growth forest view near site where metate was found. **b** View from Chachi sacred waterfall

Janzen (1998) takes this view when he argues for considering wild nature as a garden to change the prevailing philosophy of conservation. Some forests have a relatively small human footprint. Others are mostly human artifacts (e.g., apêtê in Brazil, Anderson and Posey 1989) or Quichua-enriched trailside gardens (Fig. 13.6). Instead of natural and anthropogenic, all humans live somewhere along a continuum of vegetation types from "natural," with a small human footprint, to the urban and suburban landscape, which is almost completely defined by human activity (Fig. 13.7). The botanic garden, therefore, becomes an ideal venue for examining the human–nature relationship.

13.2.3 Gardens Are Underutilized

Despite their potential for both teaching and research, most botanic gardens are underutilized. This is not a recent trend. Avery (1957) wrote, "Most people have the idea that a botanic garden or an arboretum is a park without a place to play games", a place where plants bear labels with unpronounceable names—something like an old-fashioned museum. These are sometimes the 'outdoor laboratories' of colleges and universities, generally little used except for a few class field trips each year or for student recreation."

Fig. 13.6 Trail near Cashinua along Rio Napo Ecuador. Quicha plant edible fruit species along trail to provide snacks for their children who use the trail to walk to school

The reasons for the underuse of botanic garden as teaching resources are myriad. Proximity nurtures collaboration and utilization. Unless a garden is situated within a college campus, logistical problems, such as transportation and parking, ensue. Gardens need to provide adequate classrooms (both indoor and outdoor) and facilities to support education. Interpretation and labels are lacking or inaccurate in many gardens. Most botanic gardens struggle to balance the four primary tasks of research, conservation, display, and education. Research and education often are the losers. Yet, when properly planned, each task can benefit the others.

Gardens should be a primary venue for teaching from K–12 to the graduate level. Most organismal botany courses from taxonomy, morphology, anatomy, physiology, economic botany, and ethnobotany could be better taught in a garden than in a standard classroom, especially if the garden provides some classroom/lab space. At the very least, garden excursions should supplement on-campus activities.

Besides teaching, accessioned, vouchered, and properly identified garden collections are excellent sources of research material. Too often students now study plants exclusively in the lab, with no conception of the plant in natural environment. Two graduate students strolling through a college campus were discussing their research projects. One of them, studying the phylogenetic position of a particular species confessed of never having seen the plant that was the focus of her doctoral

Fig. 13.7 a Suburban yard landscaped with native trees from southern Florida. **b** Tropical hardwood hammock, southern Florida. Both sites have a similar species composition. The first is completely anthropogenic, the latter is dominated by natural processes

dissertation. Her companion quickly pointed to the plant, a common weed growing in the brick pathway on which they walked. Dr. Mark Chase, one of the premier plant molecular phylogeneticists, wrote of the inspiration that comes from looking at both the DNA and seeing living specimens of the species that he studies, a process he called "reciprocal illumination" (cited in Marris 2006). Many phylogenetic, morphological, anatomical, phytochemical, and reproductive biology studies would not be possible with garden-grown plants. A researcher could collect material from any reasonably sized botanical garden and discover new plant compounds and new types of biological activity, for example. Studies of seasonal variation in plant natural products is another topic well suited for gardens.

Yet, gardens may be even better suited for studying the people–plant relationships. Every garden visitor interacts with the garden as a whole as well as with individual species. Why do they visit gardens? Do they have a home garden? Do any species have particular significance for them? Scores of other questions remain unanswered. In ethnically diverse cities such as London, Miami, or New York, garden visitors come from around the world and they bring their own unique knowledge and lore about many of the plants. This collective knowledge is an untapped goldmine.

Fig. 13.8 Fairchild Triopical Botanic Garden, Coral Gables, FL

13.3 Personal Observations

I have taught courses in botanical gardens for more than 30 years. As an M.S. student at Florida Atlantic University, I first visited FTG, then known as Fairchild Tropical Garden, as a plant taxonomy teaching assistant. As a Ph.D. student at the University of North Carolina, I frequently taught local flora and plant taxonomy labs at the North Carolina Botanical Garden. Since 1992, I have taught a variety of Florida International University (FIU) botany courses at the National Tropical Botanical Garden's Kampong Garden, Montgomery Botanical Center, University of Miami's Gifford Arboretum and especially at Fairchild (Fig. 13.8). I also have taught field courses in southern Florida, the Bahamas, Ecuador, Panama, and Peru, which has given me a perspective on the merits and pitfalls of both field and garden-based teaching.

FIU and FTG have a long history of collaboration. From 1992 until 2006, my colleague Dr. Scott Zona and I taught at FTG's Botanical Research Center, located about a mile away from the garden (Fig. 13.9a). Space issues lead to the loss of the classroom for a 6-year period. During this time, FIU classes visited the garden on field trips but did not spend the entire semester in the garden. That changed in the fall of 2012, when Fairchild opened the Burns Building within the DiMare Science Village. The Burns Building includes a classroom/teaching lab located within the garden, and it should be a model for other gardens (Fig. 13.10). The classroom overlooks the Richard H. Simons Fairchild Rainforest, an ideal backdrop for teaching about tropical plants (Fig. 13.11). Prior to its completion, we would lecture at the offsite research center, travel with students to the garden to collect, and then ultimately return to the research center to study the plant material. The new venue alleviates the logistics of transporting students between the research center and the garden. But it does more than save time. At any point during a class, instructors and students can step outside to gather material and quickly return to the classroom/lab. Florida's notoriously frequent thunderstorms no longer disrupt schedules. Students

Fig. 13.9 Dr. Scott Zona and FIU graduate taxonomy class examining *Furcraea* sp. at Fairchild Tropical Botanic Garden

Fig. 13.10 Newly opened Joyce and M. Anthony Burns Building in Fairchild Tropical Botanic Garden's DiMare Science Village. The classroom/lab overlooks the Richard H. Simons Rainforest

enrolled in the FTG courses also are granted semester-long passes to the garden, allowing them to return for reviews as needed.

FTG has an active K–12 program, and teaching in the garden allows college students to interact and serve as mentors to the younger students. Undergraduates

Fig. 13.11 View of the Richard H. Simons Rainforest from the Fairchild Tropical botanic Garden's new classroom/lab

and graduate students also can easily attend the garden's research seminars. For teaching taxonomy, there is no better venue than a botanical garden. The diversity is unrivaled in natural areas, and most garden collections are developed to insure that there are at least some plants in fruit or flower during all seasons. And, unlike in most natural areas, student and professor usually can collect plant material, with the permission of the director of horticulture. Gardens are also excellent venues for teaching about useful plants. It matters little where economic plant collections are labeled in the garden. Any competent instructor can visit a garden and soon discover the interesting people–plant stories to engage students. Nonetheless, ethnobotanical displays are useful for both education and interpretation. Chang et al. (2008) found that the incorporation of traditional wooded canoes in an ethnobotanical display produced more positive influence on visitor learning and perceptions of attractiveness than any other measured factor.

The diversity within a garden is a two-edged sword. While it offers the potential to expose students to a breadth of plant forms, families, and functions, it can also prove overwhelming. Whatever the subject, the optimal teaching philosophy is not to cover every topic, but rather to teach students how to learn on their own—a lesson I learned in a garden. In 1986, I enrolled in Dr. Barry Tomlinson's Harvard Tropical Botany Course, which he taught at Fairchild (Fig. 13.9b). Midway through the course, we visited the nearby USDA Chapman Field. Half the class went with Dr. Tomlinson and the other half toured the collections with a Harvard colleague, who co-taught that year. I wisely opted for Dr. Tomlinson's group. After 4 h we reconvened and someone from the second group asked how many plants we had seen. The Tomlinson students conferred, and then replied "four." The second group was incredulous. "How can you spend 4 hours and see only four plants?" It was a result of Tomlinson's teaching style. For each of the four species, we began by looking at plant architecture, and then moved on to morphology and anatomy. Next, we dissected flower and fruits. We concluded with a discussion of the plant's taxonomy and biogeography. The hour we spent with each species seemed to pass quickly.

Fig. 13.12 Chachi House exhibit at Fairchild Tropical Botanic Garden

Professor Tomlinson knew that there was far too much for a neophyte or even an expert to grasp during a single visit. His objective was broader—to teach us how to learn on our own. I still remember the four plants that we saw, and I doubt that students in the second group could name a single species or a single fact about the myriad of species they encountered that day. I try to employ Professor Tomlinson's approach with my students, but I must confess that I am seldom as successful as he was. Gardens are wonderful places to teach about plants. They are better places to teach students how to learn on their own.

Another thing that gardens offer that cannot be duplicated in natural areas is the ability to destructively sample material. During the Harvard course, the class dissected a banana plant, a ginger relative (including roots), a large cycad, and a coconut palm among many others. While observing slabs we cut from the trunk of the palm, I was struck by how effective living material is for teaching. Every botany student has sat in a lab looking through a microscope at a cross section of a lily stem. Yet, we could learn just as much about monocot anatomy by examining the coconut palm stems. Moreover, observing the palm sections was a visceral experience. We had collected them and knew how they related to the whole organism.

The four functions of a botanic garden—research, conservation, display, and education (Wyse Jackson 1999)—are often viewed as competing for limited resources. They should be seen as mutually beneficial. In 1996, I planned an ethnobotanical display for Fairchild. In October, we shipped an entire Chachi house, four dugout canoes, and scores of traditional crafts down the Rio Cayapas to the town of Borbón, Ecuador. From there, the material was transported by truck to the port city of Esmeraldas and packed in large shipping containers. A few weeks later, the material arrived in Miami, soon followed by three of my Chachi colleagues: Pedro Añapa, Manuel Añapa, and Miguel Chapiro. During their 2-month stay in Miami, we erected the Chachi House at Fairchild, with help from my graduate students and garden volunteers (Fig. 13.12). During its 5-year span, the Chachi House and adjacent garden proved to be one of the most popular exhibits in the garden (display). Interpretive material and interactions with the Chachi were an invaluable experience for my students and for garden visitors (education). The project contributed to my long-term study of Chachi ethnobotany (research) and helped publicize the loss of the Chocó forests of Ecuador as, well as the threats to the Chachi culture (conservation). Artifacts from the exhibit continue to be used in Fairchild's education program, which reaches 50,000 K–12 students each year.

13.4 Conclusion

Botanic gardens have a long and well-established relationship with university educations and were especially important in the development of medical education, beginning in the 1500s. Today, with a shift away from organismal biology, gardens often play a minor or nonexistent role in collegiate education. Ironically, the kinds of skills many employers seek, such as plant identification, are the kinds of skills best taught with living plant and not with preserved classroom material. Visits to natural areas are important and cannot be replaced by visits to gardens. Nonetheless, gardens offer several advantages over natural areas with respect to teaching. These include accessibility, diversity of collections (including species from around the world), and the ease of repeat visits for review. The respite from frenetic college campuses and the aesthetics of gardens foster an environment conducive to learning and creativity. Spending class time outdoors also is a refreshing change and allows students to ponder the human–nature relationship.

FTG's new classroom/lab and its collaborative relationship with Florida International University serve as a model to foster university education. It has allowed the garden, in the words of Walter Lewis, to become "the classroom and laboratory of the botanical community." Fairchild's new facilities include office space for faculty and graduate students and four research labs in addition to the classroom/teaching lab. It was a multimillion-dollar venture that is beyond the dreams of many gardens in today's tough financial times. The FTG accoutrements are wonderful, but they are not essential. All that is needed is classroom space and a few good dissecting microscopes. Even the latter may not be absolutely necessary. Much can still be learned about the botanical world with a good hand lens and a razor blade. Thus, with simple cutting implements, magnification devices, and a modest teaching space, any botanical garden can become a valuable venue for teaching and research. We should not miss the opportunity to teach in botanic gardens, to teach in a paradise.

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Chapter 14
Teaching Ethnobotany Through Field Research: A Case Study Integrating Conservation with Tibetan Traditional Ecological Knowledge

Jan Salick

14.1 Introduction

Training in ethnobotany is a high priority for conservation and sustainable development as well as academics. Ethnobotany is successful both in incorporating traditional ecological knowledge (TEK; for definition see Berkes et al. 2000) and a multi-constituent base into conservation and sustainable development (Gadgil et al. 1993; Toledo 2002; Berkes and Turner 2006; Salick 2012). For conservation to succeed, local people need to be integrated and empowered (c.f., Liu et al. 2001). To successfully integrate conservation and TEK, there is an overwhelming need to build capacity in ethnobotanical methods and practice. Capacity building at all levels from academia to the local community is one of the chief ways to ensure that all sectors are empowered to play an active part in conservation and sustainable development (henceforth, simply "conservation" for ease of discussion). Empowerment is particularly critical in situations where policy and decision-making emanate from distant central governments and where indigenous people are impoverished and marginalized, and poorly understood by people and organizations that control conservation processes.

Effective training in applied ethnobotany is best accomplished *in the field* (Salick et al. 2005b) with multidisciplinary and multiethnic teams of participants and trainers. In the field, people learn not only methods and practice but also become aware of unique attributes of place and people. On site (in situ), participants gain first-hand experience that only field time provides and that is needed for grounding projects in local realities. Participants with different ethnic and educational backgrounds interact as equals.

Ethnobotany increasingly guides conservation to incorporate TEK (e.g., Redford and Padoch 1992). For conservation to succeed, grassroots support and initiatives must be integrated with policy. Indigenous and local people must be the foundation and initiators of conservation for effective implementation. Ethnobotany provides

J. Salick (✉)
Missouri Botanical Garden, 299, St Louis, MO 63166, USA
e-mail: jan.salick@mobot.org

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Fig. 14.1 Ethnobotany training participants included Tibetan doctors and villagers; Chinese botanists, conservationists, professionals, and students; and Western ethnobotanists, conservationists, and students (author: *center in white*)

processes through which local people, professionals, academics, and policy makers can be drawn together and empowered for conservation. One of these ethnobotanical processes is multidisciplinary and multiconstituent capacity building in TEK.

When working with a diversity of trainers and participants it is important to define ethnobotany. Formally, it is the dynamic relationships among peoples, plants, and the environment (Salick et al. 2003). When applied to conservation, ethnobotany is local people's use and management of plants and their environment for conservation and development. The Convention on Biological Diversity (CBD) and the Global Strategy for Plant Conservation (GSPC) affirm that traditional methods of natural resource management are effective means for achieving sustainability. Thus, ethnobotany provides a solid foundation for conservation.

In this chapter, I discuss a 4-year training project funded by the Ford Foundation on Tibetan Ethnobotany in Northwest Yunnan, China. Participants (Fig. 14.1) included Tibetan doctors and villagers; Chinese botanists, conservationists, professionals, and students; and Western ethnobotanists, conservationists, and students. The goals of this training program were multifaceted:

- Capacity building in applied ethnobotany for conservation and sustainable development
- Facilitation of interdisciplinary and interethnic partnerships for conservation
- Application of traditional ecological knowledge to conservation including local cultural practices for maintaining and enhancing biodiversity

These goals are universal enough to apply to teaching ethnobotany under many circumstances. Here, I offer our experiences to ethnobotanists and conservationists concerned with multidisciplinary and multicultural training.

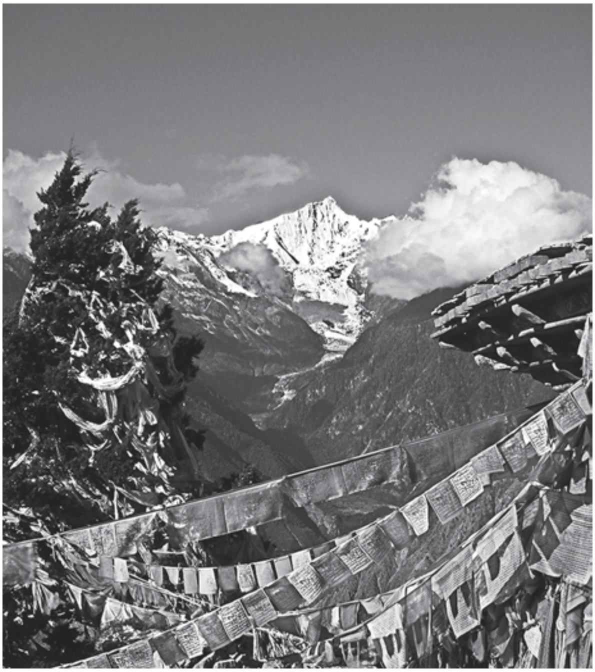

Fig. 14.2 Ethnobotany training took place in Tibetan villages around sacred Mt. Khawa Karpo (6,740 masl) and glacier

14.2 Tibetan Ethnobotany in the Eastern Himalayas

14.2.1 Training Site

The eastern Himalayas—verdant, snowcapped, and glaciated—are renowned for their biological and cultural diversity and endemism (Mittermeier et al. 1998). Tibetan people (*Kham*) have lived for millennia in this area, conserving, using, managing, and enhancing this diversity (Salick and Moseley 2012). Diversity and endemism evolved in the eastern Himalayas, brought about by monsoonal rains, precipitous topography of geological uplifting and the great rivers, and the interplay of major tropical and temperate floras. Tibetan culture flourished in this diversity and developed conservation and management to use and protect it. Outstanding among this biological and cultural diversity is a mountain range dominated by a peak known to Tibetans as *Khawa Karpo,* the warrior god, among the most sacred peaks in Tibet, and the highest peak in Yunnan Province, China (Fig. 14.2; 6,740 m). The sacred geography of this area is profound, protecting and conserving biodiversity (Anderson et al. 2005; Salick et al. 2007; Salick and Moseley 2012).

Ethnobotany, the study of plants and people, is employed to document the useful biodiversity of *Khawa Karpo* and indigenous methods of conservation and management (Salick et al. 2005, Salick and Moseley 2012). Native plants, including foods, medicines, fibers, dyes, oils, construction materials, and much more, are used by

Tibetans in every aspect of their lives. From the mundane to the sacred, from subsistence to ceremony, plants are an integral part of Tibetan life. Conservation and management of plants and biodiversity are equally integrated in Tibetan culture. How can we reinforce these indigenous traditions of conservation?

Tibetan land management is relevant to conservation. Conservation and sustainable development professionals and organizations can learn from and reinforce indigenous Tibetan practices at many levels from landscapes to plant populations. Tibetans have been successful stewards of this plant diversity for millennia. However, modern pressures brought on by transportation, markets, and interests in herbal medicines are threatening traditional land stewardship and, in the process, threatening the plants themselves. Tibetan ethnobotany studies of indigenous systems of Tibetan land management can reinforce conservation and empower the people to defend their resources and manage them for a sustainable future (Salick et al. 2005; Salick and Moseley 2012).

14.2.2 Process

This training project took place over 4 years and included several components not often incorporated into training courses: Our multidisciplinary and multicultural constituency was incorporated in (1) needs assessment and project design; (2) development of training; and (3) participation; including, (4) the multifaceted training and research; (5) subsequent ethnobotany projects, both applied and academic; (6) presentation of results; and (7) evaluations. Here, these components are described in more detail.

14.2.2.1 Needs Assessment and Project Design

It is important to integrate the greatest diversity of perspectives into ethnobotany training and conservation from the original project conception to final implementation, evaluation, and reporting. Open interviews with local villagers, village leaders, local and nonlocal professionals, government and nongovernment organizations (GOs and NGOs), professors and students helped to give a broad-based view of needs for conservation and sustainable development and for ethnobotanical capacity building. This helped to set priorities and objectives for both training and conservation. Prior informed consent was received from all those interviewed and participating at all stages of the process.

In Northwest Yunnan, China, we conducted assessment interviews in Tibetan villages near Mt. *Khawa Karpo,* in the county (*Dechen*) and regional (*Diqing Prefecture*) seats, and in the Yunnan provincial capital of Kunming. Near *Khawa Karpo,* villagers, village leaders, and Tibetan doctors were interviewed. In Dechen, a conservation GO (Three Rivers Conservation Commission), an NGO (The Nature Conservancy TNC), and the county Tibetan hospital were contacted. In Shangri-la, the Shangri-la Alpine Botanical Garden, two NGOs (the Center for Biodiversity and Indigenous Knowledge (CBIK) and TNC), and the regional Tibetan hospital were consulted. In Kunming, several academic institutions (Kunming Institute of Botany (KIB), Yunnan University (YU), Southwest Forestry (SWF), Chinese Academy of Science (CAS)), and NGOs (TNC and CBIK) were surveyed.

The needs assessment called for capacity building in ethnobotany in Northwest Yunnan, including skill training in ethnobotanical plant collection, remote sensing (GPS) and geographic information systems (GIS), participatory rural appraisal (PRA), applied Ethnobotany and quantitative analysis training followed by specialized training in advanced scientific methods such as use of molecular techniques, population ecology, and policy in ethnobotany. Needs were identified for integrating ethnic and occupational perspectives including Tibetan villagers, Tibetan doctors, conservation professionals (Chinese and Tibetan), and academics in ethnobotany, anthropology, ecology, and botany. Tibetan locals needed introduction to goals and practices of conservation and ethnobotany. Chinese unfamiliar with Tibetan culture and environment needed cultural training and field experience to appreciate indigenous wisdom and place.

14.2.2.2 Development of Training

To be truly interdisciplinary, it is important to develop a training structure that integrates disciplines rather than distinguishes them. By focusing on a common research topic, disciplines and skills can be integrated such as ethnobotanical collecting, GIS, PRA, and applied ethnobotany for conservation. Nonetheless, some segregation, especially for advanced scientific training, is inevitable because people involved have different backgrounds and access to resources.

For the *Khawa Karpo* area, we chose land use and change as topics critical to conservation, which we could simultaneously investigate and use to teach participants about the *Khawa Karpo* area and local *Kham* Tibetan people. Land use and change are issues addressed by farmers, geographers, botanists, conservationists, developers, academics, and local people. *Khawa Karpo* is of both sacred and secular importance for Tibetans who have vast TEK about plants and their environment. Tibetan TEK has been accumulated, related, and taught orally for generations; even so, lifestyles and cultures are always evolving. To understand land use and change we employed ethnobotanical techniques to document plant use, land use, religious and cultural practices, and socioeconomic conditions.

14.2.2.3 Participation

A close association of peoples of different ethnic, gender, educational, and professional backgrounds is necessary for a project to be truly intercultural. This can be facilitated by simple association: by assigning shared rooms, by learning, eating, and playing together, and by forming mixed teams that spend weeks together in

Fig. 14.3 Tibetan doctor leads prayers at the sacred glacier (center with Tibetan texts). Six Tibetan doctors participated in the ethnobotany training to teach plant use and customs

the field. This does not preclude differences and trainers must be prepared to work with these.

Participants in our ethnobotany capacity building included six male and six female villagers from the six *Khawa Karpo* villages in which we worked. These people simultaneously were trained in ethnobotany and conservation, while they taught about traditional land use and change, customs, and socioeconomics; they subsequently led applied ethnobotany projects in their villages. Six Tibetan doctors (Fig. 14.3)—highly respected leaders who should be powerful partners in conservation—took part in the workshop both to learn ethnobotany and conservation and to teach plant use and sacred precepts of land use and culture. Six ethnobotany students, three men and three women, from various Yunnan universities were trained in ethnobotany and Tibetan land use; they subsequently conducted research in Tibetan ethnobotany for master's theses. Staff from the Missouri Botanical Garden (MO), KIB, TNC, CBIK, and SABG participated as teachers, facilitators, and investigators; these men and women subsequently worked with applied ethnobotany for conservation in *Khawa Karpo*.

14.3 Teaching Ethnobotany near Sacred Mt. Khawa Karpo

Ethnobotany training consisted of seven components: (1) introduction of ethnobotany, people, goals, methods, and schedule; (2) fieldwork on traditional land use and change; (3) reconvening and planning; (4) advanced ethnobotany; (5) applied and research ethnobotany projects; (6) reporting results; and (7) evaluations.

14.3.1 Introduction of Ethnobotany, People, Goals, Methods, and Schedule

Several days together as a large group allowed participants to get to know one another and address introductory topics, most notably ethnobotany itself, conservation and sustainable development, plant collecting, repeat photography, satellite imagery, GPS, GIS, and PRA. Practice exercises were useful to learn techniques before heading into the field. Meals, tea, and evening festivities helped develop collegiality and mutual respect.

Our introduction was held at *Mingyong* glacier extending down from *Khawa Karpo* peak, which is both a Tibetan sacred and government conservation site. Modest tourist bungalows with multiple beds per room housed multicultural groups of participants; the associated "restaurant" was known for serving wild foods, making ethnobotany more tangible. Meetings and festivities were held in the Three-Parallel Rivers Management office built for government conservation projects. Trilingual translation was continuously provided: Tibetan, Chinese, and English to assure equal status and understanding among all participants. Our Tibetan doctors drew unanticipated crowds of local people (Fig. 14.3) who have little access to medical care; this too reinforced ethnobotany of Tibetan medicine and highlighted the doctors' status, which make them such important conservation leaders. A little drink, a little dance, a little song made the process casual and enjoyable.

14.3.2 Fieldwork on Traditional Land Use and Change

Three groups of participants trekked to two villages apiece: six villages total. Each group comprised a woman and a man from each village, two doctors, a translator, two university students, and resource professionals for GIS, PRA, and ethnobotanical collecting. Villages were selected *a prior* to represent environmental and social variables affecting the region. Food, lodging, and prior informed consent were prearranged. Groups stayed for 5 days per village, collecting land use data.

In these six traditional villages, field activities included:

1. Detailed inventory and mapping of fields, pastures, and gardens on mobile devices with GPS capabilities loaded with satellite images of the villages;
2. Ethnobotanical collection of useful plants in noncultivated habitats to assess nontimber forest product diversity;
3. PRA assessment of land use by villagers using free hand mapping techniques (Fig. 14.4). These maps were then compared with satellite images;
4. Discussions with village elders of village and land use change using historical photographs from the early 1900s (Fig. 14.5).

Villages were selected systematically to include three villages near roads and three villages far from roads; additionally two of the villages were at high elevations

Fig. 14.4 Participatory rural appraisal (PRA) mapping provided details of villagers' land-use management, conservation, and sacred sites

Fig. 14.5 Land-use change discussions were prompted by sharing historic photographs of botanist Joseph Rock from nearly 100 years ago

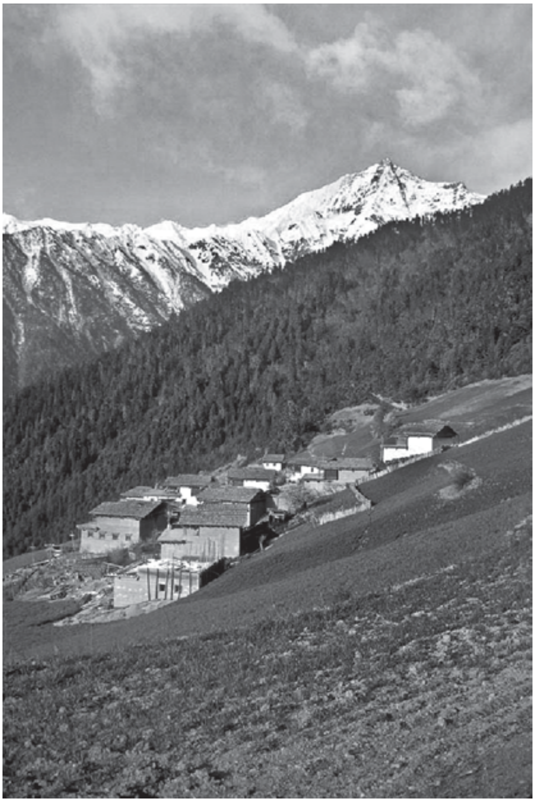

Fig. 14.6 High-elevation villages have more extensive croplands with more diverse subsistence crops and a higher percentage of traditional Tibetan crops

(Fig. 14.6; >3,000 m) and four at lower elevations (<2,500 m). In this way, we could compare the effects of road access and elevation on land use. Tibetan villages where fieldwork was conducted are located as much as 2 days trek along steep mountain trails. Gear, food, and personal effects were packed on horseback, including kerosene plant driers and fuel. An early monsoon season further hindered progress, so that even some roadside villages were blocked by landslides. Nonetheless, the teams were absolutely dedicated to gathering huge quantities of data and completing the exercises. Land-use change discussions were prompted by sharing photographs of botanist Joseph Rock from nearly 100 years ago (Fig. 14.5). Repeat photos of the same scenes were taken to document change (Salick et al. 2005; Salick and Moseley 2012).

14.3.3 Reconvening and Planning

After 2 weeks in the field (including travel), we reconvened as a large group for 2 days to compile and discuss data and results. Another 2 days were dedicated to designing and presenting future ethnobotany projects, including six applied ethnobotany projects, one in each village where we worked, and six ethnobotany thesis projects, one by each of the participating university students. These projects were presented to and reviewed by the whole group of villagers, doctors, professionals, academics, and students. After a final party, participants returned home.

Briefly, results from Tibetan land use showed (see Salick et al. 2005 for full data and results) yearly crop rotations in the highlands and biannual rotations in the lowlands. Croplands are more extensive and subsistence crops are more diverse in the highlands. Highland households cultivate a higher percentage of traditional Tibetan crops than do lowland villages (Fig. 14.6). Households close to roads grow significantly higher percentages of commercial crops and employ more modern technology (e.g., fertilizers, pesticides, plastic sheeting) than villagers without road access. The convenience of road access presents a trade-off as villagers travel farther to access forest, alpine, and pastures resources. Interviews with village elders and examination of photos from historical botanical expeditions indicate that the last century has seen agricultural intensification, afforestation, and an increasing participation in cash-based economy. Climate change is causing dramatic changes in the environment, land use, and culture (Salick and Byg 2007; Salick and Ross 2009; Salick et al. 2009; Byg and Salick 2009; Salick et al. 2012; Salick and Moseley 2012).

14.3.4 Academic Ethnobotany Skills

Ethnobotany students conducted research on academic projects for their master's theses. Student theses included studies of use and efficacy of traditional green manures; traditional Tibetan walnut varieties associated with matrilineal families (Gunn et al. 2010); human impact on and management of native oak forests; use, harvest, and management of sacred plants; and effect of harvest on Tibetan medicinals (Law and Salick 2005, 2006; Salick et al. 2006; Byg et al. 2010; Law et al. 2010; Salick and Law 2011).

One of the most consistently identified needs of academic ethnobotanists was for training in advanced scientific techniques including quantitative methods, population and community ecology, and molecular techniques. For this aspect, the academics from the field course reconvened at Kunming Institute of Botany and were joined by other ethnobotanists and by professors who taught specialized skills. In fully equipped computer and molecular labs, specialists taught technical skills to academics. These techniques were used to analyze ethnobotany data of the project theses. Students documented their processes and results, which were presented at the International Congress of Ethnobiology, Kent.

14.3.5 Applied Ethnobotany Projects

For 2 years subsequent to the initial ethnobotany capacity building, villagers conducted applied ethnobotany projects including building two Tibetan medical clinics, one local primary school where Tibetan TEK was part of the curriculum, and reforestation/agroforestry projects using native trees. The original trainers—Tibetan, Chinese, and American—facilitated these projects and outside experts were brought in to support the work as needed. All projects demonstrated impacts on conservation and sustainable development of the *Khawa Karpo* area.

14.3.6 Reporting Results

In ethnobotany, it is extremely important and ethical to continually consult with and return results to the people with whom data were gathered. It is vital that results should be interpreted in conjunction with local people who know the place and culture and appreciate implications. This consultation and reporting took place at various stages: during and after the assessment, during and after the data collection, after the analyses, and before and after the student and village projects were completed. At these stages, trainers and students met with participants and returned to the villages where our training and research was conducted to discuss data, results, and interpretations. We solicited input and suggestions from Tibetans who were intimately familiar with land use and change. These group interpretations played a very constructive and instructive role in designing and interpreting data collection and scientific results.

14.3.7 Consultations and Evaluations

Ethnobotanists independent of the training project were brought in for advanced training (above) and also to consult on ethnobotany projects in the villages, both applied and student, and to evaluate the project as a whole. These consultations allowed ethnobotanists who were not directly invested in the process to support and evaluate the process from fresh yet experienced perspectives. Those of us imbedded in the process sometimes missed obvious weaknesses or contradictory elements. Independent evaluation allows donors to verify the value of their contributions and, more importantly, gives valuable feedback to educators by which to modify or reorient their processes. Both praise and criticism must be given constructively and received equitably.

14.4 Conclusion

Ethnobotany is the study of relationships among plants, people, and the environment. As a discipline, it has developed from the study of indigenous peoples and their plant use and management into an emerging multi- and transdisciplinary field. With the close association of traditional people and their environment, they have accumulated detailed TEK and apply this knowledge to sustainably managing natural resources. In turn, ethnobotany can support conservation and sustainable development in understanding and integrating traditional sustainable natural resource management into rural development and biodiversity conservation. Ethnobotany elucidates the methods and rationale of traditional livelihoods. To do so, a diversity of participants must be trained in ethnobotanical methods.

It has been shown repeatedly that conservation is ineffective without local support (Liu et al. 2001). Ethnobotany provides the tools through which TEK and conservation objectives can be integrated. Here, we provide a training model for accomplishing these goals. Meaningful conservation and sustainable development projects are best developed in the field with inputs from manifold perspectives.

For education, the value of this ethnobotany training model—teaching ethnobotany in the field to multidisciplinary and multicultural participants—is in bringing together people of diverse ethnic, educational, and professional backgrounds to address meaningful issues and to learn from one another. All participants—indigenous people, local experts, conservationists, professionals, students, and professors—are teachers and all participants learn. In the field, we address reality and lay aside preconceptions.

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Chapter 15
Excursions in Teaching Plant Science Through the Local Ethnobotany of the Food–Medicine Continuum: Field Trips to Traditional Specialty Food Markets

Cedric Barrett Baker and Gokhan Hacisalihoglu

15.1 Introduction

New paradigms are emerging in the ethnobotany of food as it relates to the ethnopharmacology of the food–medicine continuum (Baker 2010). Historical traditional medical systems (e.g., Traditional Chinese Medicine, Unani-Tibb/Islamic, Greek and Byzantine, and Ayurvedic systems to name just a few) have used combinations of plant-based foods in raw, processed, and cooked form, with the various forms of condiments as seen in regional cuisines (e.g., tajines from North Africa or curries from Southeast Asia) that also make extensive use of herbs and spices in the various preparations that are used as tonics in preventive medicine. This is a foodway that all traditional healing systems have shared (Anderson 2005; Chen 2009). This methodology predates recorded history (Navarro et al. 2010). Traditional cultures account for between 75 and 80 % of world healthcare systems, and the use of plant foods and medicines is a major part of their primary care (Blumenthal 2011). The transmigrations of cultures and plants have evolved some unique biocultural niches that have led to some interesting studies in the ethnobotany of the food–medicine continuum (Anderson 1988, 1996; Dogan et al. 2004; Pieroni and Quave 2007). Urban areas and rural areas give a contrast in this dynamic through such avenues as cultural hybridizations and population density of ethnic groups within certain geographic locales. The transmission and preservation of traditional knowledge systems informs this dynamic, and can coexist in many oral and written forms in

C. B. Baker (✉)
Department of Pharmacy Practice/Center for Clinical Research CCR-15,
College of Pharmacy and Health Sciences, Mercer University, 3001 Mercer University Drive,
30341-4155 Atlanta, GA, USA
e-mail: cedric@yak.net

13300 Morris Road, Unit 32, 30004 Alpharetta, GA, USA

G. Hacisalihoglu
Department of Biology, Florida A&M University, Tallahassee, FL, USA

C. L. Quave (ed.), *Innovative Strategies for Teaching in the Plant Sciences*,
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an ethnically plural biocultural niche (Canclini 1995; Khaldun 1967; Nazarea 1998; Rasmussen 2006).

A prime example of various traditional knowledge systems can be found in regional cuisines and also in the local ethnobotany of the food–medicine continuum (biocultural niche construction), which can be accessed and explored in traditional specialty food stores, which includes local ethnic markets, restaurants, and grocery stores. Lectures that preface the field trips by detailed information on the culture and biology of the traditional plant-based functional and medicinal foodways of the biocultural area to be explored are made manifest and reinforced by the practicality of actual hands-on use of the plants during the field trips to the various traditional specialty food stores (e.g., ethnic markets, restaurants, and grocery stores) in a local area (Albuquerque et al. 2012).

15.1.1 Classification of Foods

Traditional Chinese nutrition therapy makes little distinction between food and medicine. The use of ginger (*Zingiber officinale* Roscoe) in this unique traditional ethnomedical approach is a good example of medical value of foods that are assigned classifications, such as heating (as opposed to foods that are cooling), supported by the ying and yang cosmology of Taoism in an ecological context of increasing complexity (Anderson 1988, 1997; Kastner 2009). Ginger is extensively used to prevent and treat colds and cold symptoms in traditional Asian medical systems, and it can be seen that a hot food treats a malady of cold. Traditional Chinese medicine use of the longevity elixir green tea (*Camellia sinensis* (L.) Kuntze) is a special case of a medicinal food whose virtue of power as a chemopreventive agent is evidenced in numerous epidemiological studies, and a tradition of use for more than 2,000 years as a tonic drink (Huang 1999; Lee and Shen 2008; Yang 2002). Traditional Thai dietetics and medicine is even more seamless, with a tighter nexus found of the food–medicine continuum (e.g., in medicinal Thai curries) than that of even other traditional Asian healing systems (Anderson 1993; Salguero 2003).

Ayurvedic medicinal food traditions include dietary therapy as a part of every treatment plan and employ a specific classification of the physiological and pathological effects of foods based on food quality and taste. Ayurvedic tradition holds furthermore that diet therapy is more effective after shodhana (Dhruva et al. 2009; Tiwari 1995). Spices and the phytochemistry of taste is an area that lends itself to be explored easily in the classroom, and practically applied in field trips to traditional specialty food markets and grocery stores. This concept can be experienced as the taste of the spices as they are used in situ. Latin American, South Asian, Southeast Asian, and Middle Eastern groceries and ethnic markets often hold a variety of spices. Many times, these may also be found in a little snack shop found adjacent to the grocery or contained inside the market store itself. Such snack shops usually contain many native foods prepared using the spices, which can be sampled. Local ethnic restaurants may serve as alternative (or additional) ways in which some of the ethnobotanical concepts can be explored. This is an example of using plant science with the ethnobotanical lens as a way to interest students in field trips to ethnic markets, restaurants, and groceries, which can be serve to enrich the lecture material and serve as actual learning experiences at the same time (Duke et al. 2003; Morgan 1997; Nabhan 2004).

15.1.2 Teaching in Urban Environments

Expanding upon the didactic relationships of plants and their ethnobotanical uses and the dynamic of this plant use in human cultures in urban areas (e.g., Atlanta metro area with an estimated population of ca. 7 million), one generally finds that a greater density and variety of ethnic minority populations congregate to form multicultural environments as opposed to rural areas where traditional knowledge may possess a different quality and demographic profile. For example, in the Atlanta metro area, there are several such areas of multicultural convergence that are ideal for ethnobotanical field trips. This method of integrating the ethnobotany of local ethnic cultures into lesson plans can be accomplished by having students observe the inventory and day-to-day interactions in some of the larger multicultural markets (such as those found in the Buford highway area of metro Atlanta). We have explored this method in detail with the intent of designing a field trip based on the actual plant inventory range of fruits, vegetables, herbs, spices, herbal teas, and other natural medicinal botanical products that are sold and used daily.

15.1.2.1 Design of a Field Trip for Pharmacy Students

Our field trip was designed from the context of lectures on the ethnobotanical, ethnobiological, ethnomedical, and ethnopharmacological properties of traditional Thai botanical natural products (e.g., garlic, shallots, green onion, turmeric, galangal, krachai, ginger, kaffir lime, lemon grass, coriander, holy basil, roselle, bael fruit, durian, mango, mangosteen, and bitter melon) used in traditional Thai dietetics and medicine. Looking from the perspective of the ethnopharmacy of plant-based functional and medicinal foods and foodways, one finds that the ingredients in a traditional Thai functional/medicinal curry are the same as the recipe that is consumed every day as a traditional part of a tonic diet that is specific to a Thai locale (Salguero 2006, 2007). A more general Asian dietary pattern with tremendous health benefits is consumed throughout South Asia, Southeast Asia, Japan, and China.

Permission and partnership with the market(s) was always procured before the trip in order to maximize student exposure to aspects of the market (i.e., assigned plant or plant families) that are being covered in lecture. Upon return to the classroom, loose samples of plants and photographs from the excursion may be explored in more detail. Field trip topics can be expanded on or modified to include a look at cultivars of spices, fruits, eggplant, bitter melon, tea, rice, and other items specific to local ethnobotany, and how they are used as foods and medicines and other related issues (Cost 1988; Iriti et al. 2010a; Vasanthi and Parameswari 2010).

Our field trips were designed to enrich the content of a Pharmacognosy course in which the excursion follows a lecture on the ethnopharmacy and medical ethnobotany of plant-based foods. Likewise, another field trip was designed to follow the annual grand rounds lecture in the PHA 650 Pharmacotherapy Case Studies course, in the "Phytopharmacotherapy Case Studies" series given annually at Mercer University, College of Pharmacy and Health Sciences. There are certainly many applications of the field trip model that can be useful in the education of health science students from the undergraduate level of pre-medicine, pre-pharmacy, and pre-nursing majors to the professional educational level of pharmacy, medical, and nursing students.

15.1.2.2 Lessons in Cultural Competency and Drawing Connections to Plants

In addition to their utility in exposing students to different lessons pertinent to botany and taxonomy, the field trips were also designed to instill a tangible opportunity for students to develop cultural competency in the context of the multicultural environments for pharmacy practice and the practice of traditional herbalism. More specifically, examples of the close connection of Asian dietetics to the practical plant-based therapeutics of a healthy diet and lifestyle patterns (e.g., Asian conceptions of traditional dietetic Chinese materia medica/dietetica) were used in this teaching model. Using examples from the scientific literature, students are taught that the subtlety and depth of traditional knowledge are immense in oral traditions. For example, an ethnomedical survey of medicinal plant use in a Yi ethnic group in the central part of Yunnan, China reported for the first time the recording of 25 new curative uses and 40 new preparations out of the 875 documented plants in the Yi materia medica (Long et al. 2009). The translational dynamics of traditional Chinese, Thai, Indian, Pakistani, Latino, and Korean pharmacy practice in the USA has resulted in interesting hybridizations that are located across the country, including a few examples of the cultures just mentioned in this same Buford highway area of Atlanta. Towards this goal of cultural exposure, several traditional pharmacies were visited, observed, and a few gave permission to bring students to the designated traditional Asian or Latino pharmacies and integrative medical practices to hear lectures and see demonstrations of herbal compounds being prepared by wise and respected traditional elder physicians and herbalists, who have mutually established a relationship with the instructors and preceptors of the specialized courses to integrate the pre-field-trip lectures with the field trip lectures and demonstrations and then collectively develop methods of assessment of learning outcomes (Poirier et al. 2009).

The experience of offering guest lectures (Baker) to undergraduate students in plant biology, ethnobotany, and botanical medicine courses in innovative programs found at Cornell University, Emory University, and Florida A & M University over the last 3 years in the areas of traditional functional and medicinal plant-based foods and foodways, ethnobotanical perspectives of medicinal and aromatic plants, and the history of botanical pharmacy and pharmacology in Asia and Europe has led to the development of lectures and the idea of field trips for undergraduates. Topics for field trips could include the evolution of the human diet and the importance of the coevolution of plants and humans during the formation of these unique human diets in major centers of agricultural and horticultural development. The modern day realities of our ethnic markets in terms of produce, spices, nuts, fruits, and vegetables and how to use them for health benefits is an area of great interest to our current medical, cultural and botanical sciences, and the prehistoric and historic records bear out this fact (Martin 2004). The next sections will explore this topic and develop the didactic context of the lecture before the field trip and then look at the ideas for pre- and post-trip test questions.

15.2 Pre-Field-Trip Lecture Model

In this example of the pre-field-trip lecture model, the focus will be on the evolution of the human diet and cultural centers of superfood development. This model will look at three regions of superfood (traditional functional and medicinal food) development and a detailed look at three plant-based superfoods from each of the superfood cultural centers within the context of the ethnobotany of superfood use in relation to the food–medicine continuum and biocultural niche construction in the evolution of superfoods.

In the context of the pre-field-trip preparation the scope of the coverage of cultures, geography, history, botany, and ethnobotany of plant-based medicinal foods and superfoods can be expanded and the number of plant-based foods doubled to approximately 20 plants if two lectures are used (or more plants can be added as more lectures are added). The example of an undergraduate plant anatomy mandatory course for science majors in the module development in Sect. 15.3 covers the additional lecture added to make two lectures total in advance of the field trip/practical lab learning experience. The central theme in this lecture, which can be expanded into a series of lectures or even a course, is the prehistory to historical evolution of studies of primates and human cultural uses of plant-based foods as medicines, a perspective that moves from zoopharmacognosy to ethnopharmacognosy.

15.2.1 Centers of Superfood Development

Cultural centers of superfood development include the Inca agricultural and horticultural pioneers that hold a long tradition that is still living as there are traditional scientists of the trans-Andean corridor (that runs from northern Chile and Boliva, up through Peru, to southern and central Equador) still very active in the current day. Inca science developed quinoa and other superfoods. Lecture points on quinoa might include the nutritional superfood qualities and the unique phytochemical makeup of quinoa (with high fiber, vitamins A, B_2, E, minerals, lipids with high content of metabolic products oleic acids and linoleic acids and high protein content contributing essential amino acids). Aspects of ethnomedical use include: the use of the seeds and leaves as traditional functional foods and beverages; whole plants use as animal food; nutritional and medical use to boost the immune system and the circulatory system; and topical medicinal applications from Inca traditions. The enumerated ethnobotanical uses have all been confirmed in modern nutrition and medical science. The ethnobotanical story of how quinoa and its traditional use was conserved in the Inca culture that fled to the high Andes (as the Spanish brought their own plant foods to replace quinoa in the conquest) is a study in the sustainable diet (Vega-Galvez et al. 2010).

Mexico is the home to amaranth and the Aztec development of the chile pepper (*Capsicum annum*) into a supermedicinal plant-based food that is used all over the world. Three spices are explored from Asia for ethnobotany and medicinal culinary use: two of which are from the Zingiberaceae family and are used throughout Asia (*Zingiber officinale*, ginger and *Curcuma longa*, turmeric) and the other from Central Asia (*Allium sativum*, garlic), which are easily found as ubiquitious spices with various brands in most markets and groceries. All three are super medicinal foods and condiments with synergistic chemopreventive properties that came out of Asia. Turmeric is another showcase superfood developed in South and Southeast Asia. Lecture points include the fact that it is one of the world's oldest domesticated plants and one of the most studied and promising chemopreventive agents for many chronic diseases. Curcumin and other curcuminoid compounds in turmeric are currently under study in clinical trials, and the efficacy seems to be due to the pleiotropic synergy of the constituent compounds in turmeric (Jurenka 2009).

For the last examples of superfood development in different cultures, we will look at the Middle East, North Africa, Europe, and western Asia, which have given the world botanical natural products such as olives and olive oil, saffron, and dates. Lecture points could discuss the ecology of the date oasis and the complete food quality of dates as superfoods as they contain high amounts of fiber and are also rich in vitamins and minerals (Nabhan 2009). Olive oil and the Mediterranean diet is a topic that has stimulated much interest as evidenced by the recent output of literature on the Mediterrenean diet (Panagiotakos and Polychronopoulous 2005). The anti-inflammatory properties of olive oil phenolic compounds that are synergistically augmented by the neuroprotective melatonin content (which reaches its highest levels as a component in the Mediterranean diet in the form of extra virgin olive oil) is an interesting topical lecture point (Iriti et al. 2010b; Fig. 15.1).

15.2.2 Utilizing Local Resources

This is only a model, and the plant foods used medicinally and as preventive medicinal (chemopreventive) agents can be changed or gathered from the instructors

Fig. 15.1 Sample food plants and spices in Istanbul Spice Bazaar, Turkey

own local ethnobotany of surrounding markets. In places of sparse multiethnicity of local markets, innovation like resorting to a chain grocery store has opportunities as most chain grocery stores have an ethnic food section in their stores. Field trip venue possibilities abound, depending upon the local circumstances. Chain natural food stores sometimes house a great variety of ethnic produce and many localities have regional cooperative markets (co-ops). The local ethnobotany of the food–medicine continuum is constructed by the immediate environment of biology and culture where one resides (anywhere one lives has its own unique ethnicity/culture). The adaptability of this model is flexible. Pre- and post-field-trip test questions can be developed from the pre-field-trip lecture and the lectures and demonstrations that are part of the field trip/practical lab learning experience. In the design of pre- and post-field-trip test questions and field trip/practical lab assignments, we have found that it is most useful to focus on understanding of plant part(s) used, culture-specific processing of the plant food and how it is used within a cultural context as medicine.

15.3 Pre-Market-Trip Activities and Pre-test

There are various methods that might be used to teach plant sciences at the high school and college level (Hacisalihoglu et al. 2008). Field trips may be an ideal way to use course modules for enhancing student learning experiences and stimulating interest in the plant sciences. In this chapter, we report constructing plant biology

Fig. 15.2 Sample food plants from local specialty food markets in Florida. **a** Bok-Choy. **b** Egg-plant. **c** Ginger. **d** Guava. **e** Karela. **f** Dragon fruit. **g** Turmeric. **h** Yucca

knowledge by using visits to local specialty food markets (Fig. 15.2). The food markets specialize in diverse quantities of food plant species and varieties that may not be easily found elsewhere. Furthermore, helpful market staff or guests can guide and teach about usage of the various food plants. The specialty food market field trip is an educational lab program that can be conducted by the faculty instructors to study diverse food plants from around the world. Student learning outcomes of this field trip exercise are:

- The market trip will be incorporated into a lecture course of elementary plant biology
- Students will learn about common and scientific names of major food plants, herbs, and spices from around the world
- Students will learn about the ethnic origin, folklore use, modern science or health or medical use of major food plants, herbs, and spices from around the world

An important part of the pre-market visit is to teach students basic principles of plant biology including plant taxonomy, ethnobotany, plant morphology, as well as plant identification. Therefore, pre-market-trip activities should include required reading assignments to acquire a basic plant biology background. The plant lectures and reading assignments provide a focus for the proposed market trip module. Thus, the pre-field-trip lecture and field trip/practical lab module should be developed and used after the class has already covered basic botanical science.

Furthermore, students' prior plant biology knowledge can be measured with a multiple-choice pre-test based on the educational activities that will be performed at the market visit (e.g., Table 15.1). The significance of this lab module will be its focus on local specialty food market plants that are being consumed in the daily environment but are not being utilized commonly for teaching in the plant sciences. The other important goals of the lab module include the stimulation of student interest in plant science and learning gains concerning the health benefits of traditional plant-based functional and medicinal foods, and how they are used in a cultural context.

15.4 Market Visit Activities

Specialty food markets may be model places for learning about plant species, their native countries, and their usage. Students can be prepared for the market visit by utilizing two lectures, plant samples, and a slide presentation of the overall range of specialty food markets inventory and plant details prior to the visit day. The field trip location can be to one of the largest specialty food markets that is located within the same town. These specialty food markets typically consist of specialty fruits, vegetables, herbs, and spices that are targeted from ethnic cuisines worldwide such as Asian, Middle Eastern, and Latin American traditional foodways. During the market visit, students will spend 3 h as a lab period exploring the aisles featuring the plants, herbs, and spices from three major regions of the world's superfood plants.

During the specialty food market visit, each student can be given the following topics to cover in the identification of 10 different food plant species out of 20 plant species covered in the lecture:

- Common name
- Scientific name
- Ethnic origin and geographic range of the plant species
- Key characteristics of the plant species
- Folklore or ethnobotanical use of plant species
- Modern health use of plant species

These student activities not only help students to understand the importance of plants but also the role of their use in human health and the daily diet. At the end of the specialty food market visit, a brief presentation to students by staff or faculty related to ethnic food plants and their importance is useful for summarizing major learning points. Specialty food markets offer a rich and diverse variety of food plant species, herbs, and spices. The shelves and aisles of these markets may be an ideal source to study vegetables and fruits from around the world in a practical lab module. The instructors for the field course trip/practical lab module can also obtain samples of all plant materials studied during the field trip to bring back to the lab/classroom for post-market-trip activities assessment of student learning and to be used additionally in the class as the occasion dictates.

15.5 Post-Market-Trip Activities and Assessment of Student Learning

Following the specialty food market visit, students should participate in post-trip activities including turning in the plant identification assignment from their visit. Furthermore, student learning of this lab activity can be assessed with a post-test, which is identical to pre-test (see Table 15.1). The final survey questionnaire should be given after the field trip/practical lab module (Table 15.2). Our past observations have shown that the practicality of the specialty food market field trip increases student interest in plants and the plant sciences. Assessment of the success of this innovative idea for teaching in the plant sciences can be gauged with the pre- and post-test question scores and the post-market-trip final survey questionnaire. This idea and methodology can be used in a plant anatomy course as well as courses in ethnobotany/ethnohealth and botanical medicine at the undergraduate, graduate, and professional health science levels.

15.6 Final Survey and Conclusions

Plant biology is becoming increasingly important and one of the most popular fields in the biological sciences. This market field trip model may be a promising and practical avenue for instructors to use to increase student learning and interest in

Table 15.1 Sample pre- and post-test questions developed for students in market trip module

Q.1-10) Indicate what major ethnic food region does each food plant belong. (A: Asian; L: Latin American; M: Middle Eastern).

Q.1) _____	Monk Fruit	Q.6) _____	Amaranth
Q.2) _____	Lucuma	Q.7) _____	Persimmon
Q.3) _____	Jalapenos	Q.8) _____	Quinoa
Q.4) _____	Ginger	Q.9) _____	Chickpea
Q.5) _____	Olives	Q.10) _____	Tomarillos

Q.11) Give an example of super food that has 10x more Vit. C compared with citrus fruits?

A) Pitaya B) Golden berry C) Monk fruit D) Acerola cherry

Q.12) Give an example of a super food that has 10x more lycopene compared with tomatoes?

A) Pitaya B) Gac fruit C) Monk fruit D) Acerola cherry

Q.13) Give an example of plant whose bark can increase insulin activity?

A) Ginger B) Golden berry C) Garlic D) Cinnamon

Q.14) Give an example of a plant that can reduce blood pressure, cholesterol, and melt plaque?

A) Garlic B) Ginger C) Monk fruit D) Mint

Q.15) Give an example of a plant that is often used for digestion and to sooth stomach upsets?

A) Pitaya B) Golden berry C) Basil D) Mint

Q.16) Give an example of a plant that is often used to heal burns / skin disorders?

A) Garlic B) Golden berry C) Geranium D) Aloe vera

Q.17) Give an example of a plant which contains capsaicin and is used for pain relief ?

A) Basil B) Cayenne C) Eucalyptus D) Cherry

Q.18) Give an example of a plant that can help stress, anxiety, and digestive problems?

A) Dandelion B) Cayenne C) Cohosh D) Chamomile

Q.19-22) Match the scientific name (on the right) to the common name (on the left).

Q.19) ____	Bok choy	A) *Monihot esculenta*
Q.20) ____	Turmeric	B) *Curcuma longa*
Q.21)____	Cassava	C) *Lens culinaris*
Q.22) ____	Lentil	D) *Brassica rapa*

NOTE: The correct answers are: 1: A; 2: L; 3: L; 4: A; 5: M; 6: L; 7: M; 8: L; 9: M; 10: L; 11: D; 12: B; 13: D; 14: A; 15: C; 16: D; 17: B; 18: D; 19: D; 20: B; 21: A; 22: C.

Table 15.2 Sample student final survey used in this course for students participating in the specialty food market trip

1. What year of school are you in?
2. What is your major?
3. Your interest in plant sciences?
4. How did you participate in this market trip?
5. The best part of the food market trip was:
6. The worst part of the food market trip was:
7. I'd like to see more:
8. Would you recommend the food market trip to other students?
9. What are your overall observations of the excursion and what have you learned about plants?
10. How do you rate your plant market excursion (excellent, good, average, poor)?

plants. Specialty food markets may be model environments for learning about plant varieties and their economic, culinary, and medicinal usage.

A final survey questionnaire should be given out and a survey conducted at the end of this lab module. In this final survey, students will be asked to reflect on the field trip and visit the effect of this learning experience on the students' interest and knowledge of plant biology. As shown in the final survey questionnaire (see Table 15.2) in Sect. 15.5, students will be asked about their overall observations as well as the best part of the field trip/practical lab and suggestions on how to improve the field trip. At the end of the course, student plant identification reports, pre-tests, and post-tests will be analyzed to find out if field trip/practical lab is an effective module to enhance teaching and student learning and interest in plant biology.

In conclusion, this pre-field-trip lecture and practical lab module can provide students with exceptional plant science learning experiences and potentially prove to be a very effective and innovative method to help teachers interest students in the plant sciences. Current medical anthropology and transdisciplinary studies such as those currently found in medical ethnobotany and ethnopharmacy view the phenomena of health and illness as comprised of biological and cultural components (Wiley and Allen 2009). A biocultural approach to the ethnopharmacology of food was the foundational work of Nina Etkin, and this is where the ethnopharmacy of plant-based foods and foodways takes its base (Etkin 2006). Students are often interested in the health benefits block of the lectures due to various factors such as personal experience with an obese child, a parent with a chronic disease, or a student who has a family history of a chronic disease. The current health care environment with obesity linked to all of the chronic diseases associated with inflammation (Marsland et al. 2010) finds our new paradigm coming to center stage with such topics as anti-inflammatory foods such as olive oil, fish oils and various spices, nuts, fruits, and whole vegetables. The anti-inflammatory functional food components like the ones found in the spices ginger (gingerols) and turmeric (curcuminoids) are in human clinical trials in various cancer chemopreventive and chemotherapeutic regimes, and in cardiovascular disease primary and secondary prevention protocols (Rowe and Davis 2008). It is currently mandated in medical and pharmacy education requirements that students receive instruction and experience in effectively relating to the cultural backgrounds of patients. Also mandatory is instruction and exposure to the various practices of complementary and alternative medicine. Lastly, patient demand is also making it necessary for students of medicine and pharmacy to become experts in health and wellness as a public health and clinical practice approach (Weinberger et al. 2010).

Plant-based whole food nutrition and traditional dietetics give Western biomedicine an integrative base to develop medicinal food therapeutics. This scenario entails a lot more of our science, medical, and pharmacy students studying plant science. We see this new innovative model and module development as a great way to naturally interest undergraduate science majors, pre-medical majors, and pre-pharmacy majors and also students of horticulture, nutrition, cultural studies or even liberal arts. There is virtually no downside, and the rewards are potentially multifarious for using this model in undergraduate plant science classes and in courses for students in the health professions.

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Chapter 16
Ecosystem Excitement: Using Everyday Items, Projects, Field Trips, and Exotic Images to Connect Students to Plants

Maria Fadiman

16.1 Introduction

Excitement about plants can generate interest in the environment. The angle from which I approach botanical education is through connecting students to plants by highlighting human uses. Most societies value plants with which they are in direct contact (Fadiman 2007). In order to link students to flora, I bring common items into class that promote student-driven discussion, facilitate student-organized mini projects that encourage self-reflection about the students' own plant use, bring the class on field trips to bring them out of the theoretical understanding and immerse them, literally, in the topic, and in my larger classes show exotic pictures of faraway places and people to pique learner curiosity.

The first three teaching techniques fall within the framework of self-directed learning (SDL), experiential learning (EL), and place-based learning (PBL). Each pedagogical method is an active learning strategy focusing on student participation and self-guidance. Studies show that these methods promote an in-depth understanding of natural landscapes and ecosystems (Louv 2008).

SDL is when the students actively promote their own learning with varying levels of guidance, obtain resources, put into action ways of learning, and then assess their own results (Knowles 1975). EL is when the student learns through actively engaging in the topic, increasing understanding by initiating their own questions (Hawtrey 2007). PBL, which is often outdoors, encourages understanding how natural ecosystems and humans connect. Outdoor environments promote learners' involvement with their surroundings. Studies show that combinations of these methods help students retain information while connecting them to the subject matter in a way that encourages future engagement with the topic (Louv 2008).

M. Fadiman (✉)
Department of Geosciences, Florida Atlantic University, 777 Glades Road,
Boca Raton, FL 33431, USA
e-mail: mfadiman@fau.edu

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Using aspects of these methods, I try to teach my classes in ways that foster interest in ecosystems and the plants that grow in these biological arenas. Although I utilize the SDL, PBL, and EL with my smaller graduate classes, these could be modified to accommodate both undergraduate and larger classes. For the most part, class topics revolve around people's everyday lives. For example, students explore their own connection to plants as they eat their breakfast, walk on their lawn, and drive to school. Through noticing and learning about their own use of plants, they then can branch out to study plants at a more in-depth scale. For my larger classes, I show striking pictures in an effort to "wow" them with what is different, while personalizing the images with the familiar.

16.2 Common Items as Teaching Tools

As a way to introduce the semester's topics, I bring in common items for the students to see and touch drawing from SDL and EL techniques. The physicality of the items helps elicit the class' thoughts and personal memories.

16.2.1 Chocolate

The first item I hand around is chocolate. They each pop a candy in their mouth silently sucking and watching me. I turn to my white board and write the word "chocolate." They smack their lips. I write the scientific name *Theobroma cacao*. I then ask, "What does *Theo* mean?" Someone says "God." I explain that "*broma*" is Greek for food, and then ask why chocolate would be named after something so divine. The students begin to call out what they know, prompting others' thoughts. The discussion takes off: Someone has heard about Aztecs using the seeds as tribute in Mexico, which leads another to talk about the plants' original geographic location and how it was consumed as a drink. Someone mentions eating the fruit on the outside of the seeds, which leads to a discussion of why the fruit tastes so sweet while the seeds are bitter and how that relates to dispersal. People chime in about how colonization played a role in our adoption of chocolate in its current form, how the processed plant now relates to gender, holidays, and marketing, and how cacao grows in plantations to fulfill this desire. We move on to what that means environmentally, and why it is a cauliflorous plant, and so on.

They build on each other's comments, while I write their thoughts on the white board. As people begin to call out their ideas, the discussion usually becomes increasingly dynamic as the students become more eager to get their ideas on the board. If the conversation lags, I will ask a general question to help move them into an unexplored angle. They then begin again, asking and answering their own questions as a group. Starting with a mouthful of chocolate, they connect to the plant and all that the species includes botanically, culturally, and environmentally.

16.2.2 Genetically Modified Organisms

Another example is for the topic of agriculture, specifically genetically modified organisms (GMOs), and conventional and organic farming. I place a can of corn on the table. They talk about the current geographic growing areas in the Midwest, the plant's origin in Middle America, how use reflects place-based growth such as cornbread in the southern USA and tortillas in Mexico, the role of high-fructose corn (HFC) syrup and the role this product plays in our foods, why farmers use corn as feed for animals meant to consume grass and the students own personal memories of corn at picnics, and how this grass relates to socioeconomic groups and the kinds of restaurants in which you would find corn on the cob, and where you would not. They discuss how fresh corn relates to the seasons, how the plant itself grows, the pollination structure of the silk, domestication, and teosinte (the theorized precursor), and how production relates to pesticides, herbicides, and the development of GMOs.

16.2.3 Other Topics

For other topics such as gardens, I bring in potted basil and for ornamentals, a cut rose. A little baggie of turf grass gets them thinking about what the lawn means to each of them and to society, a palm frond for religious plants and an apple for both biblical references and current national identity. They bring up the phrase, "American as Apple Pie" and then we note the real geographical location from where apples come. I turn the label of my cotton shirt to them and we consider textiles, and their historical cultural significance in terms of race, ethnicity, and the environment. For biofuels I bring in a bag of sugar, and they talk about Brazil and corn and the reality of fuel and the environment. For the topic of mental stimulants and depressants, I bring in a potato and coffee beans, and they discuss how plants are central to their weekend parties and their morning after cup of java. A bottle of aspirin introduces medicinal plants and the dominant role these species play in our medicine cabinets, although often unseen. The last item I lay on the table is a fish trap that Amazonian indigenous people wove from plant fibers, to bring up the topic of how people use plants in rural areas. However, the foreign item only comes out after we have established how important plants are to all of us here, at home, every day.

16.3 Mini Projects

Utilizing both SDL and EL, the students design weekly mini projects for each other based on the assigned class topics and readings. A group designs the assignment for their classmates (and themselves) about what personal observations all will make during the week. The class writes these down and then verbally shares their interpretations in the next meeting. The overall point of the projects is to have them stop and notice plants in their own lives. Because these assignments come from themselves for each other, students invest energy in devising thought-provoking ideas. Of the many projects they have given to each other, I have included a few examples here.

16.3.1 Foraging

For the class topic about foraging, students asked each other to hunt for plants around their homes, paying attention to ripeness of fruit (thus noticing the season and what naturally grows where and when) and safety (noting the connection to plants outside of the presumed security of the supermarket and to make sure no one eats anything poisonous). Students came into class with animated stories about how many fruit trees grew in their neighborhoods and exchanged tips with each other on where certain plants grew on campus. One year, a student from Vietnam noticed that plants from her tropical homeland grew in Florida, and explained to the class about some of the less recognized fruits and medicinal plants.

16.3.2 Organic/Conventional/GMO

The students provided a chart about how to analyze produce stickers, and asked each other to read the labels of their own produce and determine if a food was organic or conventional, consider GMO possibilities, and contemplate if any of these aspects mattered to them. People came in surprised at their own plant food choices and the marketing of the concept "natural." Students had different opinions about how important these issues either were, or were not, to them, especially in terms of economic realities. As they explored their own relationship to plants in their everyday life, they looked at how these issues affect their buying practices and vice versa.

16.3.3 Exotic Species

The students addressed the issue of exotic species by having their classmates look at the animals and plants on campus, determine what organisms were exotic, and if the class saw these nonnative organisms as a problem. Then, the organizers asked their classmates to compare their campus observations with the last natural area they visited. The students needed to pay attention to the plants they saw every day with those in protected areas. The class then considered their observations in the context of invasive exotics, local ecosystem health, human influence, and their own role in the situation. A lively discussion, focusing quite a bit on raccoons, developed.

16.3.4 Lawns

Students asked the others to measure their own lawns and write down who cared for the grass and if that caretaker (themselves or another) used chemicals. Then the group asked the class to write about how they felt about their yards. This required the class to reflect on what the lawn landscape has come to mean within the American aesthetic. The organizers also asked the other students to observe their neighbors' grass upkeep, and for the student to record their own opinions about neighborhood appearances and environmental sustainability in terms of water, pesticide, and monocultures. People were particularly passionate about this topic, on all aspects of the issue.

16.3.5 Ornamentals

Students asked each other to mark down how many house plants they had (if any), why they chose to have them, or not, and what the participants "got" from these organisms. Through doing this project, students noticed how botany was a part of their everyday life and what kind of "use" the organisms provide. They explored what about plants attracts people so much, that as a society many exert effort to ensure that they keep these entities in close proximity.

16.3.6 Medicinal Plants

Students asked their classmates to think of any family remedies or other plant-based cures for ailments. Many came in and discussed herbal teas and natural pills from health food stores. Some students brought in plants that they had picked from their own yards with healing properties. Students enthusiastically exchanged notes about what they used.

16.3.7 Useful Plants

The leaders asked their classmates to bring in a piece of a useful plant, and the table overflowed with vegetation. This activity required the individuals to seek out plants, consider their connection, find a way to pick a specimen, and bring the item into school. Various students brought in flowers, other fruits, and some medicinal leaves. One had a small branch from a large tree which she described as providing shade. We sat around the table, each with their plants displayed eager to explain their findings to each other

16.3.8 Natural Areas

In looking at the connection beyond individual plants, students had their classmates go to a natural area and describe what they saw and felt. The organizers decided it was useful to have each other look at how plants help create an ecosystem and what they get from an intangible angle. Students came in with stories of parks, favorite benches, woods, yards and how much it meant to them to be able to stop, look, and feel these areas.

16.4 Field Trips

In addition to SDL and EL, field trips incorporate PBL as well. Initially, I was resistant to field trips. I wanted to avoid the hassle of finding a place, contacting organizers, arranging rides, sorting out the timing, and dealing with students' off-site discomfort. Although of these fears were indeed realized, they were well worth the effort. The students' actual experience of plants about which they had read, developed additional pathways for learning. Since the goal was to foster enthusiasm about plants and conservation, discussing these issues surrounded by the vegetation and the passionate people who created these spaces, affected the class in ways that indoor discussion could not.

16.4.1 Alana's Butterfly Plot

We discussed anthropogenic influences on landscapes and how these fit into our understanding of nature and control. This topic became more integrated into reality when we visited the local garden of a butterfly expert, Alana. She and her husband had turned their yard into a natural habitat, utilizing native plants, such as *Passiflora cuprea,* to create a balanced ecosystem that attracted butterflies.

The field trip began with students sweating in the Florida sunshine outside of the air-conditioned classroom setting. Alana brought them through her yard, stopping at certain plants to discuss how the specimens attracted butterflies, birds, and other insects She emphasized the interaction of flora and fauna and the intricacies of pollination and dispersal. The students began to reach out to touch leaves and smell flowers. Watching a butterfly pollinate a plant in front of their eyes ignited curiosity and from their questions, appeared to increase the ease with which they absorbed the concepts.

16.4.1.1 Student Requirements

In order to have the students reflect on what they experienced beyond the facts of the environment, I assigned them to look at their own personal data incorporation.

After Alana gave the tour, each student needed to find a spot in the garden to sit, contemplate, and write about their experience. There were no set criteria. However, I did give some possible guidelines for those who worked better within a more structured format, such as for them to discuss their expectations, surprises, emotions, and ideas. Initially, I had concerns that people would find the assignment too "weird" and be resistant. However, each student quietly sought out a place. After 15 minutes we regathered in the garden and discussed what they wrote.

16.4.1.2 Their Reactions

In contrast to my anxiety about their discomfort, many mentioned that they would have liked more time (as mentioned earlier, students came up with a similar assignment for each other after the field trip). Students shared about feeling peaceful, understanding ecology at an emotional level, and mostly about being inspired. They talked about how seeing this space helped them realize that a native garden is feasible. They were able to recognize how their own cultural perceptions of landscape aesthetics and neighborhood policies could now reflect a new awareness.

16.4.1.3 Written/Quantifiable Results

They then formally wrote up their assignments and turned them in to me in the next class (one student was inspired to write a poem in addition to the assignment). The papers universally mentioned the lack of time to sit in nature, and that being required to be still amongst plants as a class assignment gave them the opportunity to observe the natural world and see what they normally would not. Furthermore, for topics throughout the semester such as introduced exotics, pesticides, and cultural norms of aesthetics, they would bring up Alana's human-constructed "natural" area, flourishing without pesticides or fertilizers. Their sensibilities about what was possible began to shift, opening up new possibilities in our classroom discussions about what could be achieved, long after we left Alana's garden.

16.4.2 Pine Jog Elementary School

Another example of a field trip that inspired people to associate with plants was at Pine Jog Elementary School in Palm Beach County, FL. The facility was a public school that emphasized institutional goals as a green establishment and accentuated the environment in their curriculum. As we toured the school, students listened and asked their obligatory questions. In contrast, when the director took us outside to show us the fourth-grade fruit and vegetable patch, the college students came alive.

Ripe strawberries dripped from trellises, and when the science teacher came out to talk with us, seeing the students' eyes fixated on the fruit, she offered to let each one pick a berry. This tapped into a part of them I had not previously seen. Fully animated, they chose their berries and relished the flavor. Inspired by the strawberries in their mouths, the class started a barrage of questions about planting, pests, sun, water, and the basic ecology of plants. The science teacher's answers generated more involved student questions. When the students turned in their reflection papers the next week, most highlighted the strawberry experience. A few of them had even purchased small berry plants for their porches. All of them had always been able to access strawberries in stores. However, there was something about being able to pick, touch, and eat the organism while watching them grow that brought a heightened sense of curiosity about plant ecology.

16.4.3 John's Backyard Garden

Drawing from the Pine Jog strawberry excitement, a year later for a different class, I included more garden readings and organized a trip to a backyard food garden. John had planted a garden that he turned into a personal study in which he quantified all input and output, creating a website called Just One Backyard (http://justonebackyard.com/), and his own doctoral research explored urban gardening. John began the field trip by taking the class around his garden, starting with the point that he converted a lawn space into an edible plant ecosystem. He explained what he had planted, how his compost worked, referenced the bamboo he grew to make his own trellises, and why he used cypress mulch (natural to the region).

Although his emphasis was not on native plants (students asked), it was on generating as much produce as possible. And if he could, he used as few pesticides as possible. The latter goal led him to plant the part of his yard that he referred to as "The Prairie," in which he raised wildflowers and grasses. This "natural" habitat nurtured predatory insects, keeping down infestations in the edible plant portion. Discussing the environmental function led to further questions and conversation about ecology.

John amazed the graduate students (and their professor) when he dug up a jicama *Pachyrhizus erosus,* the large white, crunchy, consumable root with which we were familiar. However, we had never seen the vine and learned that the jicama plant itself (other than the root) is poisonous. This sparked later discussion about plant anatomy and defense systems. Lastly, he took us to a wall covered in planter boxes filled with lettuce, spinach, and arugula. He emphasized that lack of yard space was not a deterrent to growing food.

16.4.3.1 Picking/Eating

The interaction enlivened when John gave the class baskets and clippers. Initially shy, the students stayed put, holding the cutters gingerly. John leaned down to pick and a student copied him, encouraging the rest. As people chose leaves of chard and green beans, they began to talk with each other and look at the plants more closely. After they filled their baskets, the class stood in a semi-circle while John washed each item, explained what it was and handed each student a tasting piece.

As we bit into the produce the class had picked, one morsel at a time, people exclaimed about flavor and freshness and questions began to flow as they looked to John and each other for answers. The more everyone had a little taste of something that they had just seen growing, the conversation became more animated. John ended the tasting with slices of mango he had frozen from his tree in summer.

John offered leftover vegetables to the students, who tentatively accepted and then eagerly appreciated, helping each other pack up the items. When John picked flowers at the end for people to take, the students immediately handed them to the one student who had taken the fewest vegetables. They were looking out for each other in a way that there was no need to do in the familiar classroom. After the class time officially ended, the group continued to linger and ask questions. Finally, I had to herd them home.

The majority of their reflection papers discussed how it made them want to start a garden. This connection with growing and their inspiration to obtain their own plants encouraged them to educate themselves about ecosystems, predators, photosynthetic needs, and hydrology. Moreover, their wanting plants in their own lives increased their direct connection to botany, possibly morphing into larger botanical interests. Ensconced among plants with passionate people talking about these spaces, the field trips touched students in a way that the classroom could not.

16.5 Pictures

The previously discussed methods were used in small classes, emphasizing plants in our own lives. Working from another angle, in larger classes I use pictures from my travels (or they could be anyone else's) to have students see global uses of plants, and how people in rural areas connect to the natural world. One of the initial pictures I show is of a hand holding a half-eaten fruit (Fig. 16.1). The fruit is not recognizable, and it is unclear to whom the hand belongs. The image has the forest in the background, the hand appears to be male and indigenous, and the nails are long and full of dirt—rain forest dirt from working in the woods. The image is simple and open to interpretation, and shows the reverence for plants by a human.

In some instances I tell stories about the places and people in the pictures to emphasize that the images depict real ecosystems and human beings. Sometime these "stories" are just what occurred in the moment I took the picture. Even these simple additions can bring the moment to life. My aim is to tap into students' curiosity about places and peoples different from them themselves, while simultaneously helping the learners identify with whom and what they see. The following are just a few examples of ways I use pictures. Endless possibilities exist.

Fig. 16.1 Hand-holding rainforest fruit

16.5.1 Food Plants

Starting with concepts with which everyone is familiar, we look at food plants, beginning with colorful market pictures from Mexico. As I point to items on the screen, I have them shout out what they recognize. I then show them pictures of squash flowers and have the class think of the parts of plants that we are accustomed to eating. I show a picture of a girl in the rainforest beneath a palm tree drinking fresh *pipa* water from a young coconut (*Coco nucifera*), and I talk of how this village always had coconuts waiting for me when I arrived after hiking to their hut, and how the liquid tastes. We then discuss the reproductive strategies of palms and how plants in different phases of their life cycle produce different usable parts.

I show a picture from India of fresh produce in a city, mentioning the dependence that cities have on rural areas for food production. In the picture, a man sits amidst his vegetables drinking a cup of tea, while surrounding men look at him and laugh. I explain the men's reaction when I took the picture. The vegetable seller had put down his cup of tea to pose for the photograph. I asked if he would continue drinking to maintain the "natural" feel of the picture. The men around the stand, upon hearing me, chanted for him to pick up the cup. He finally did, and the cajolers all smiled in smug success as I snapped the picture. Although nothing "happens" in the story, the students connect with the moment and the plants and the people they see.

Describing the smell of Durian (*Durio* sp.) as the opened fruit comes onto the screen, leads me into the story of my sneaking a large specimen into my friend's house in the Philippines after she went to work. After trying the famed fruit, stuffing the extra parts into a bag which I threw in the outside trash, I had to then endure the unspoken reprimand of the housekeeper as she strode into the house and glared at me, exaggeratedly sniffing while flinging open the kitchen windows. When I then show a sign from my hotel from Thailand with a Durian fruit depicted in a red circle and a line through it, banning the fruit from the lobby, the students understand. We then discuss why the olfactory attributes have evolved this way for the fruit.

16.5.2 Natural Regions

In an effort to get students excited about plants beyond their own consumption and at an ecosystem level I start with the rainforest. The Amazon, shot from a helicopter, emerges as a sea of green. I talk about the excitement of being in a helicopter, and then to bring them back to a known comfort level, we discuss the trees in comparison to the appearance of broccoli. I then put up pictures of waterfalls and point out the spot where I would sit to write letters home and move into the importance of the local watershed and hydrology.

A picture of a tree root extending parallel to the ground for numerous meters usually brings a united gasp. Taking advantage of the students' absorption in this growth structure, I lecture about soil depth and evolutionary strategies for survival. The next photo depicts a tree dripping in epiphytes with twisting lianas. Looking at the oddity of plants with which they are not familiar piques inquisitiveness about botanical adaptations. They are then ready when we get to shade tolerant plants and I show a Philodendron (*Philodendron* sp.) with large leaves and discuss the limiting factor of sunlight for species on the forest floor beneath the canopy. The next picture shows a Philodendron house plant, which leads into why these kinds of plants work well indoors, and the economics of house plants and the industry's dependence on rain forest species.

Another example of an ecosystem is of yellow and purple flowers covering a luminous green mountain plateau that drops precipitously off into the expanse of Tibetan peaks. I then describe my own gasping as I tried to inhale oxygen at this elevation, and needing to lie down. This leads to the next photo where I show a close up of the tiny flowers, the image taken at eye level where I had flopped down in order to breathe. I emphasize the blossoms' small stature and why flowers and vegetation would be short at these elevations. I then show pandas in a Chinese reserve, wrestling and eating bamboo. As the cuteness taps into their emotions, giving them a heightened interest in these creatures, I talk about the role that this specific vegetation plays for the animals' habitat and sustenance.

16.5.3 Deforestation/Conservation

As mentioned earlier, my ultimate goal is to encompass larger ecological issues such as deforestation and conservation. After enticing the students with pictures of intact rainforest, I then show felled trees with harvesters sitting amongst the logs. I add in a story about how I accidentally ended up rooming with the loggers, and that they were, to my judgmental surprise, quite a good group. A picture of my own leg sunk in the mud brings up a discussion about how erosion exposes the muddy subsoil. I then show a picture of a small snake squirming in the mud next to my leg. The latter just helps maintain attention.

Open oil pits in the forest followed by an image of an indigenous mother who lives in the area holding a child in one hand and leaves in the other as she looks directly into my camera, opens the human/environment dialogue. Furthering this concept, a shot of an open fire with a pot of boiling leaves accompanied by my story about the locals inviting me to join in a ceremony, including the part where I was told to vomit the *guayusa* (not a hallucinogen) water, perks up their ears. I explain that although I disliked the ceremony, I emphasize the importance for the locals of the leaves and the trees on which they grow.

I then show pictures in Slovenia, Europe, indicating that environmental destruction is not limited to certain world regions. Picturesque woods with winding paths and dappled sunlight provide the back drop for the paths on which I ran each morning. I then discuss pollution and acid rain. Bringing it to the local level, I show a picture of a blonde girl wearing jeans and a sweatshirt who gave me a ride when I missed the bus. She took a back road through the forest and talked about how these woods used to be healthier. Her picture brings the local Slovenian voice into our US classroom discussion. The next picture is of the Slovenian forest again, although upon closer inspection, peeking through the foliage emerge the hat tops of the Seven Dwarves. This image tends to lighten the mood. I want them to be aware and invigorated without feeling depressed.

I then bring the discussion back to ourselves and ask for a show of hands as I call out different ways that we all use wood. I show a picture of a forest where I worked in Zimbabwe, Africa that was Forest Stewardship Certified (FSC) and discuss how our own habits of consumption and consumer decisions affect what we see in the images. In an effort to empower the learners, I then move to conservation strategies, such as the pros and cons of eco-tourism. One picture depicts mangroves lining an open waterway in the Yucatan, Mexico. I discuss mangroves' ecological importance and how these Mexican locals keep the growth intact so that tourists can do the minimally impactful activity of putting on a life jacket and floating down the water through this unique ecosystem. Another example is of Thai trees around which monks wrapped yellow cloths to protect the individuals from being cut. I include my own excitement at seeing this image after having read about them in a textbook, mentioning that in my determination to get the photo they now see, I was bouncing in the back of a truck with my hiking boots jutting into my neighbor as I scrambled for my camera.

16.5.4 Intangible Uses

To show the class non-physical uses of plant as well, I have a picture of two Maori under a sacred Kauri tree (*Agathis* sp.) in New Zealand. I then discuss my confusion when the man put his forehead against mine for what seemed like a long time. The Maori later explained to me that this was the *hongi,* the traditional greeting of sharing breath. A picture of a Baobab (*Adansonia* sp.) tree in Zimbabwe Africa then fills the screen. I tell them about locals eating the fruit and climbing the tree for honey. Furthermore, I mention the time I entered a mud hut and the women held a crying child whom she could not quiet. The man who accompanied me looked at her and walked out of the shelter. I followed as he pulled fibers from the bark of the Baobab and braided them into a necklace which he placed around the child's neck saying, "The Baobab will cure you." This serves as an example of how trees can be useful in ways that are not obvious to quantify.

The next photo shows a tree in China draped in red clothes on which people have written prayers. As I stood at the base, a girl next to me explained that people write prayers on the cloths and then throw them into the tree. She looked down at the painted cloth in her hand and said "I have a crush on a boy," and threw her own wish onto the tree. I hope for the class to be able to identify with people throughout the world having similar wishes and wants as themselves, and how these ideas can interact with the natural world.

16.6 Conclusion

Encouraging student excitement about plants and ecosystems, I try to make the botanical world accessible. To achieve this goal, I have students physically touch plants, eating them when possible, and looking at how vegetation fits into everyday life. Utilizing SDL and EL, I facilitate their coming up with ideas for each other to drive their own discussions. I also incorporate taking classes to areas where plants grow using PBL. With larger groups I use pictures of people and plants to initiate curiosity and have the exotic feel fun and different, while simultaneously humanizing the moments captured. As plants play a central role to global health, we can all learn from each other about how to excite students about the ecosystem. Putting together various strategies from different sources can help us to inspire each other as educators and our students as we guide them to educate themselves.

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Part V
Integrating Technology

Chapter 17
Teaching Ethnobiology Online at a Canadian Distance Learning University

Leslie Main Johnson and Janelle Marie Baker

17.1 Introduction

Ethnobiology is an interdisciplinary field that unites scientific biology (classification and taxonomy, botany, zoology, and ecology) with cultural knowledge of living things and environments (ethnobotany, ethnozoology, and ethnoecology). Anderson writes "Ethnobiology is the study of the biological knowledge of particular ethnic groups–cultural knowledge about plants and animals and their interrelationships" (Anderson et al. 2011, p. 1). Its primary academic roots are biological science and anthropology, though geography, cognitive psychology, environmental studies, and indigenous studies are also part of the mix. As such it is a field that is in dialogue, and fosters dialogue among diverse perspectives and understandings of plants, animals, environments and relationships, including human knowledge of and relationships to the entities that share our world. All human cultural groups live in places, environments, and depend on the living things of local, regional, and global environments to sustain them. We eat plants. We are housed by plants. We are clothed by plants. We heal ourselves with plants, still today, not only as a thing of the untutored past. Animals we depend upon eat plants, and we may eat them, or use products of their bodies to clothe ourselves, make our footwear, and many other uses. The specific ways that we humans do these things differ by the affordances of the environments in which we find ourselves and the store of cultural knowledge and values we bring to the table. Ethnobiology allows a language to consider this diversity, and look for patterns, commonalities, and differences, in the ways that peoples make a

L. M. Johnson (✉)
Centre for Social Science, Athabasca University, 1 University Drive,
T9S3A3, Athabasca, AB, Canada
e-mail: lesliej@athabascau.ca

9807 91 Ave, Edmonton, AB T6E 2T5, Canada

J. M. Baker
Department of Anthropology, McGill University, Montreal, QC, Canada

C. L. Quave (ed.), *Innovative Strategies for Teaching in the Plant Sciences*,
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living, interact with, and understand the entities of their environments. Biology matters. At the present, there is a crisis of extinction that rivals the Permian extinction. The relationships of people to plants, animals, and environments matter, so teaching about how people live with and understand these things also matters. Teaching ethnobiology is a tool to do this (Babaian and Twigg 2011; Baptista and El-Hani 2009).

17.1.1 Ethnobiology at Athabasca University

I (Johnson) have been teaching ethnobiology at Athabasca University (AU), a Canadian distance learning university, for 10 years now. When I first conceived of teaching this material at a distance, challenges included how to share visual information, how to draw on people's knowledge of local environments, given the dispersed nature of the course participants, and how to give experience when sharing hands-on teaching and learning in a single locale is not possible. Sometimes I have given optional hands-on learning as an extra-credit activity by arranging for interested undergraduate and graduate students to work with me on my specimens at the University of Alberta herbarium in Edmonton, but this is only feasible for students in North Central Alberta. As a cross-over field, ethnobiology can be approached from the cultural side or the biological side; we approach our course primarily from an anthropological orientation. The course we offer at AU is given at the fourth-year undergraduate level in our Anthropology program (Anthropology 491, ethnobiology, traditional biological knowledge in contemporary global perspective), and is also taught at the graduate level in an interdisciplinary master's program (Anthropology 591, ethnobiology, traditional knowledge of plants, animals, and environments in contemporary global perspective). Baker tutors undergraduate ethnobiology students, and Johnson teaches undergraduate and graduate ethnobiology students. Our colleague Bob Bandringa is an alternate tutor for the graduate ethnobiology class.

Undergraduate courses and some graduate courses at our institution are asynchronous, meaning that teaching is not cohort based, and students proceed through the course individually under the guidance of a tutor who may be either teaching staff (a tutor in the British sense) or a professor. Course contracts are 6 months, and can be extended if the student applies (and pays a fee) for additional time, up to 1 year. The asynchronous nature of the course adds further challenges and constraints, especially to student interaction and shared activities.

At this point in time our courses are offered on a Moodle (Modular Object-Oriented Dynamic Learning Environment) learning software platform, and feature a range of text materials, links, and forums for discussion. Communication with students is via a combination of e-mail, phone, and through interactive response in the actual grading of assignments. We include quite a bit of written work in our course, encouraging student involvement and integration of course materials through journaling and essays, and students have a choice of an essay style take-home exam, or a research paper for their final course assignment.

Our students comprise a diverse demographic, including visiting undergraduates from conventional universities, and a range of adult learners who for a variety of reasons find a self-paced distance format meets their needs. Some of our students are mothers with small children, many work full time, and another group is from remote locations in rural and northern Canada. Others are Canadians and Americans working abroad, and accessing Canadian university education through AU. Our students range in age from early twenties to mature students, some of whom have considerable life experience, and they also bring a range of prior experiences with educational settings. AU is an open university, and accepts adult learners with a wide range of educational attainment. This course requires either an introductory biology course or an introductory cultural anthropology course, or consent of the instructor.

17.2 Course Design

When initially designing the ethnobiology course, I (Johnson) sought to create a relatively comprehensive course, which would address to some degree the range of human understanding and interaction with the natural world. Case materials discuss African, American, Mexican, and Oceanian ethnobiology. I also wanted to create a course that acknowledged that we are based in Canada and highlighted Canadian experience and research. I included a wide range of traditional smaller-scale ways of making a living in the case materials and discussions, to enable a broad understanding of human relationships with, and interaction with, the biological world. This includes traditional hunting and fishing peoples, gatherers and incipient cultivators, shifting cultivators, horticulturists and pastoralists, and by way of contrast, some reflections on globalized contemporary economies. A heavy focus on complex industrialized economies and global society is beyond the scope of an ethnobiological approach and so has not been included in this course.

Key topical areas of the course include discussions of the nature of traditional knowledge, classification, ethnobotany (plant uses for food, medicine, and in technology), ethnozoology (*not* zooarchaeology, ethnoornithology, nor ethnoentomology, but what is an "animal" and how are animals understood and used in local cultural contexts, and how do they contribute to local meaning making), and ethnoecology and contemporary issues (the last including contentious issues of co-management, land claims, intellectual property (IP), non-timber forest products (NTFPs), protected areas, and the like). Archaeobotany and zooarchaeology were not included as I lack expertise in those areas and did not think a single umbrella course could encompass those topics along with the areas previously mentioned. For the focus of this volume, the section on ethnozoology does not relate to teaching botany, broadly conceived, but all other areas of the course are appropriate to examining effective teaching of economic botany and ethnobotany in a distance learning context.

The course is a three-credit course, and is organized in a series of nine units, grouped into four parts of the course. Pedagogically, the course is a hybrid between more behaviorist approaches (with Learning Objectives, and study questions for each unit) and more constructivist approaches (cf. Tennenbaum et al. 2001). The graduate course moves further away from the language of behaviorist pedagogy, and replaces Learning Objectives with Guiding Questions. We seek both to survey the content of ethnobiology (excluding archaeobotany and zooarchaeology) and to provide sufficient depth to avoid facile overgeneralization. The format of delivery is a course package comprising texts, and a Moodle site that has links to online readings and the now online study guide, as well as links for assignment upload, marking, and assignment return.

17.2.1 Course Reading Materials

At the time the course was conceived and written, there was no single text that addressed ethnobiology in the round. There were two good ethnobotany texts (Balick and Cox 1996; Cotton 1996), but neither included a synthesis of the other areas of ethnobiology, and one was not appropriate for students who lacked a strong prior background in biology. This required assembling a wide range of course materials to enable us to reach a diverse student population, and to be able to present an array of materials representing diverse perspectives and foci. Our course thus synthesizes material from a range of sources, including ethnobotany and human ecology texts, excerpts from monographs, papers from journals or edited volumes, sections from local publications and ethnographies, indigenous narratives, and “grey” literature (local reports). These materials are knitted together through an extensive study guide, really a meta-text, that features synthetic commentaries that are a surrogate for lectures, and that were necessary to contextualize and link the disparate textual teaching materials. There are diagrams and illustrations included where needed.

The reading file for our course is quite lengthy in order to present both a range of material and to examine issues in some detail. The readings have to be chosen for accessibility and “invitingness” as well as to include local people’s own words and topical issues; without the personality of the instructor present, the materials themselves have to bear more social load. We continue to use the Balick and Cox *Plants and People* text (1996), though dated, because of its excellent color photographs, interesting anecdotes, and challenging issues, which render the text accessible and make people want to know more. This introduction to a consideration of plants and cultures works especially well for those who have little background in science or in botany before the course.

17.2.2 Course Enrichment Materials

One of the challenges of education in a virtual distance setting is the creation of rich and experience-near learning. Our course incorporates a series of films that are required viewing. These are distributed by AU's library. Other options could be found such as web-based video content, but there are issues with stability, connectivity and band-width, and quality. Links to optional web-based materials (websites and videos) are placed on the course website. The approach is typical for anthropology courses, at least in our experience, though adapting the visual and audial component of learning to a distance environment is not without difficulties.

Our required films are strongly based in Canadian or northern content, helping to localize this course in familiar contexts for our students, but we also incorporate one film from West Africa that compares landscape burning with similar practices in northern Canada, adding a global dimension. The films we use include The Dogrib Birchbark Canoe (Dogrib; Northwest Territories), Make Prayers to the Raven: The Life in the Bear (Koyukon; Alaska), Rabbit Boss (Washoe; Nevada), Blockade: It's About the Land and Who Controls It (Gitksan; British Columbia); Fires of Spring (Slavey, Métis; Northern Alberta, University of Alberta), and Second Nature: Building Forests in West Africa's Savannas (Guinea, Fairhead and Leach). They complement the ethnobotany, ethnozoology, ethnoecology, and contemporary issues sections of the course.

Regarding having required film viewing, challenges have included shipping a limited number of copies of the videos to students in diverse places, and the shift of format from VHS to DVD, with accompanying copyright issues in converting formats. Thus far we have not been able to support video or DVD formats outside of the North American zone. VHS tapes and DVDs are also prone to wear and tear and sometimes students receive copies in the mail that they are unable to view, so they are not always able to view the films at the time that best fits with the rest of the course content.

Affordances of an online platform are now taken for granted, but were novel when the course was conceived 12 years ago. The original course website contained a series of links to library materials, photo galleries of Johnson's images, and links to topical articles organized by section of the course. More recently, the course was converted to Moodle. The site still contains various links to articles and online videos, as well as to the AU library and its online full text journals and e-books. The Moodle book study guide contains topical color photographs (Fig. 17.1) for each unit, and we are working on restoring, updating, and expanding the photo galleries. The graduate course still uses a print course guide, which features relevant graphics on the cover (Fig. 17.2). The graduate course also contains topical forums in which students post on the secure online course site, respond to one another's journals, and share comments on the course's topic areas. We hoped to foster interactive activities for our undergraduate students as well, but have found this more difficult to achieve. There has been little buy-in to optional chats or forums given the diversity of visiting and program students, and the small numbers at the same place in the course at any given time. There is a linked Google blog written by Johnson that discusses topics of culture and nature, but Johnson finds it difficult to keep posting on a regular basis. There are 4 or 5 years of blogs available to students as of this writing.

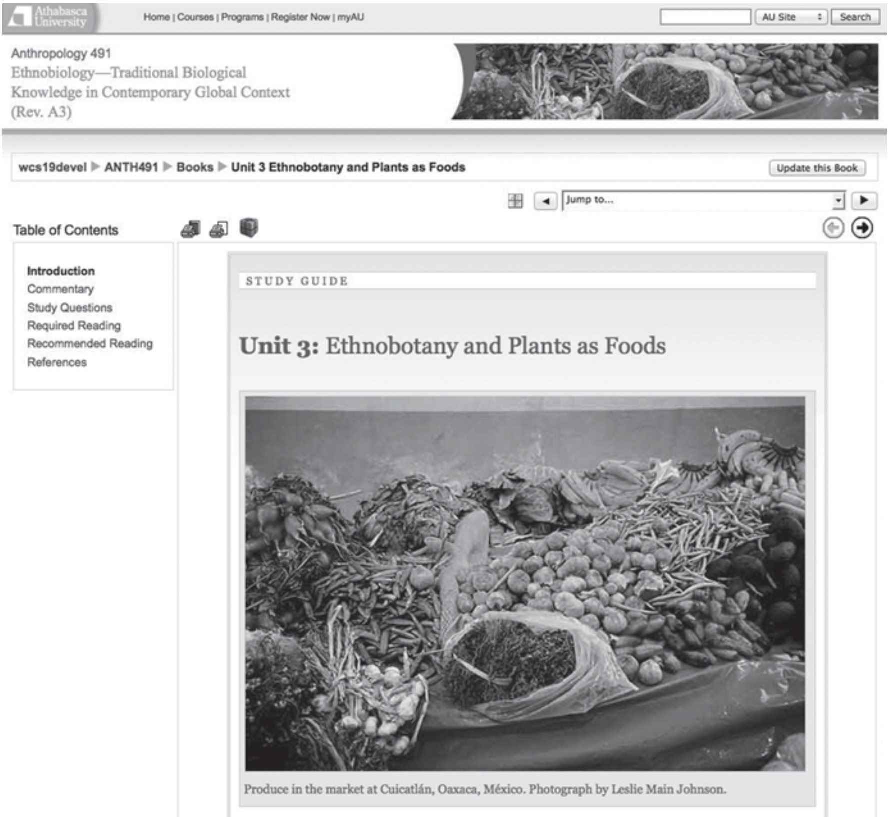

Fig. 17.1 Screen-shot of Moodle study guide, Unit 3 Ethnobotany for undergraduate ethnobiology course. Website, Anthropology 491, Athabasca University

17.2.3 Assessment Techniques

Assignments are designed to cover all nine units of the course. An initial online short answer quiz establishes tutor contact, and assesses student competence with concepts of traditional knowledge, classification, and the nature of ethnobiology. The journal covers study questions on each unit and asks students to give their evaluation of and response to the sources. Personal reflections are encouraged. The journals are submitted by course section (introduction, ethnobotany, ethnozoology, ethnoecology, and contemporary issues). Two seven–nine-page review essays or short research papers covering ethnobotany and ethnozoology–ethnoecology and/or contemporary issues are required to integrate material more broadly. Considerable latitude is allowed here, with permission of the instructor, in whether students do a simple review essay based largely on course materials, or a short topical research paper in the section area. The final assignment is a choice of substantial research paper on a topic of the student's choice or (for undergraduate students), a take-home

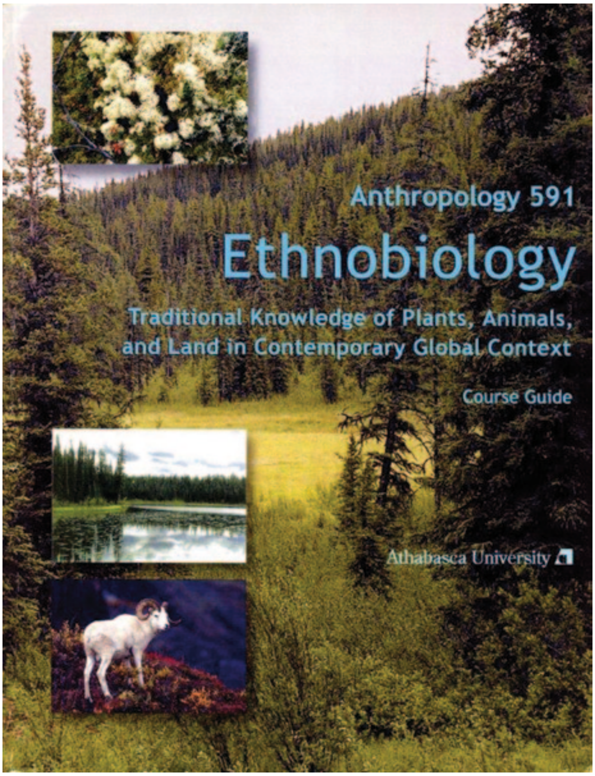

Fig. 17.2 The cover to the print Course Guide book (Johnson 2002) provided by mail to ethnobiology graduate students. Johnson's intent was to have original images that related to the course content, rather than just attractive images. The theme of these images is ethnoecological. The following caption is included on the reverse of the title page. The image of mountain sheep was a stock photo selected by the visual designer. Background: "Moose lick" *kada alésé* a meadow containing a mineral rich mud attractive to moose that is a significant "kind of place" to northern Dene hunters. This meadow is in the mountains north of Watson Lake, Yukon, and was identified by a Kaska elder during field research. Photograph by Leslie Main Johnson (research funded by Social Science and Humanities Research Council of Canada, and Canadian Circumpolar Institute, Boreal Area Research Grant). *Insets*: "Reindeer moss" or "white moss" (*Cladina* spp.), *ajú* (Kaska) muskeg area north of Watson Lake, Yukon. Photograph by Leslie Main Johnson (research funded by Social Science and Humanities Research Council of Canada, and Canadian Circumpolar Institute, Boreal Area Research Grant). 13 Mile Lake, Campbell Highway North of Watson Lake, Yukon. Photograph by Leslie Main Johnson (research funded by Social Science and Humanities Research Council of Canada, and Canadian Circumpolar Institute, Boreal Area Research Grant). Mountain sheep (Bighorn sheep and Dall sheep) are found in the montane and alpine areas of the Rocky Mountains and other ranges in western and northwestern North America. Mountain sheep are hunted by Aboriginal people in those regions. © ColorBytes Images

final consisting of essays that cover material from the entire course. Those choosing the take-home version have 3 weeks from receipt of the final to complete and submit the five required essay questions, which are submitted to the instructor via e-mail attachment. Graduate students are required to write a research paper. Research paper topics are vetted with the instructor, and research question, outline and annotated bibliography, and draft are assessed and given feedback before submission of the final paper. Automated assessments are not used. Feedback on work is detailed, as much of the actual teaching is by feedback and commentary on written assignments. Letter grades are also assigned, but the commentary is the “teachable moment”.

17.2.4 Student–Teacher Interaction

A big challenge to online at-a-distance teaching is establishing contact with students, and being “present” despite spatial and temporal separation. We communicate with students via e-mail or phone to discuss materials and answer questions. Use of email can enable prompt response not limited to specified hours (important given that students can be in varying time zones) or days, and can enable contact with the instructor wherever student and instructor may be if there is internet access. Baker uses her smartphone to monitor e-mail and maintain contact with students while maintaining a demanding consulting practice and pursuing graduate studies.

17.3 Students and Student Response

Our students include young and mature students, visiting students from other institutions, and undergraduate and graduate students from our own university. Visiting students include post-degree students as well as undergraduate majors and non-majors for our undergraduate course. The graduate course primarily serves students in the Master of Arts Integrated Studies program, but also is taken by visiting graduate students from other programs and institutions, and non-program registrants in AU’s graduate courses. Many of our students are mature students who also work, or are raising families. They bring life experience with them, and come from a diversity of settings and backgrounds (for example, stay-at-home moms, retirees, artists, physicians working in small communities in the Northwest Territories, and published authors). We have some Aboriginal (First Nations, Inuit, or Métis) students, typically from remote locations. They often find the science emphasis, especially the classification material, may be off-putting as it represents a very unfamiliar way of considering plants and animals. Some students really appreciate that they can integrate sacred and spiritual aspects of their own ethnobiological knowledge in the course along with practical insights, science, ecology, policy, and environmental concerns.

17.3.1 Successes and Challenges

In a lecture-style university course, the instructor has the opportunity to change the course layout during class, throughout the semester, and especially from year to year. Instructors can change the course content based on how the students respond to it and they can update the course materials each year. With an online course such as this, the materials are more static and changing the course content is more difficult (especially with the graduate course that has a printed manual). For example, an ethnobiology text is now available (Anderson et al. 2011) that we would like to be able to consider incorporating into the course. Of course, there are opportunities to revise the courses, but the process is more involved. This means that we live with our successes and challenges for a longer time than lecture-style courses.

We have access to the student's responses and personal reflections to the course through the journaling process (see below). Our successes include the times that the course has inspired students to continue learning about ethnobiology beyond the course and include it in their academic and applied work. Also, we find that ethnobiology is a great venue to encourage students to think about indigenous experiences (in Canada and beyond) and the human connection to the environment. If we can challenge colonial-era stereotypes about indigenous peoples, while celebrating traditional environmental knowledge, we consider the course a success (Harrell and Forney 2001). Furthermore, if we can help students from a diversity of cultural backgrounds to find validity in their own traditional environmental knowledge, the course is a success (McCarter and Gavin 2011; de Beer and Van Wyk 2011).

Challenges include keeping students in the course and on track with the course readings and assignments. With online courses we have students that we never hear from or who "disappear" part of the way through the course. It seems that when students do well with distance education, they excel in this course and flourish with the material, but some students struggle with the self-management nature of online courses. We contact students with phone calls and e-mails, to try to support students who struggle with the independent style of online learning. It is also challenging that we do not have the opportunity to do hands-on demonstration with students (such as tea-making, creative laboratory assignments, or going outside) (Poli 2001; Kendler et al. 1992). We need to inspire students to do this on their own, through the course materials.

17.3.2 Journaling

One of the main components of the course is journaling, which encourages reflection, synthesis, and integration, and enables (encourages, and at times requires) personal connection to the materials, and reflection on the implications of what is learned for ones' own life. This is a partially guided exercise, in which the students respond to study questions, and have the opportunity to share their evaluation of the unit's reading materials with the instructor. Examples of some questions that encourage connection with course content include:

- What is the importance of biological knowledge in your life and how is it similar or different to traditional ethnobiological knowledge?
- Please provide an example of a folk generic in English and two or more included folk specifics?
- What is your concept of a typical animal?

The journaling component serves several important functions in the online context of these courses. First of all, it lets the tutor/instructor know whether or not the student is actually doing the assigned readings. It also allows for a conversation to begin between student and tutor/instructor, ideally before the student submits formal assignments, so that the student can learn from comments and feedback. Although the journaling component involves a lot of writing, it is worth a relatively small portion of the grade (but is mandatory), so it gives the student an opportunity to practice writing about the course content before it really matters. The informal nature of journaling lets the students reveal more reflections and personal thoughts about the course materials than usual, which, we believe, enhances the learning process, because the students connect with the materials based on their own connection to the Canadian landscape (Babaian and Twigg 2011). Students often share their own ethnobiological knowledge or will talk about how they now see the natural world and food procurement differently. Some students will even describe how the course has inspired them to talk to family members about ethnobiological knowledge or for them to begin harvesting plants or gardening.

The students' reflections also decrease the impersonal gap inherent in online learning, as the student and tutor/instructor typically never meet in person. The journals allow a type of dialogue and getting to know one another that makes the student more comfortable to approach the tutor/instructor for guidance with the course. Also, with online instruction, student diversity is more difficult to detect (such as disabilities, English as a second language (ESL), or particular religious and/or cultural backgrounds) and often these differences are revealed in the journaling process, which helps the tutor/instructor to better understand the perspectives and needs of the students. Finally, student comments on course materials are also revealing about the student's academic backgrounds and biases and they also help the course coordinator to make future decisions about course content. For example, students often remark that they enjoy the Balick and Cox (1996) text. Inviting students to comment on the course materials also gives them a sense of agency and respect regarding their role as students in the online course, and their comments can also provide a place for some comic relief.

17.3.3 Student Response to Different Topics

The biggest challenge for many students is coming to grips with classification. My (Johnson's) notion in putting it at the beginning of the course was to highlight the nature of knowledge, and the culturally and contextually relative bases of classification, as well as to give competence in scientific classification and the nature of the "official" scientific names to those lacking that background. The readings for this section of the course, taken from Berlin (1992), Atran (1990), and Martin (1995), supplemented by readings from Hunn and French (1984) and Turner (1989), are the most challenging for students in the course. This is however, complemented by asking students to actively query their own informal classifications, and give examples of English vernacular "generics" and included "specifics." Students who already have a background in biology, especially in botany or forestry, do well with this aspect of the course, while students lacking this background may find this quite challenging.

There are contrasts between the undergraduate and graduate versions of the course. The course was originally written for fourth-year undergraduate students, and then revised to be offered in the newly opened interdisciplinary master's program in Integrated Studies in 2002. For graduate students, a higher level of analysis and synthesis, and more extensive writing seemed appropriate. In the study guide, the commentaries are the same, but the guiding questions for each unit and the study questions are written at a higher level (more critical thinking, higher in the sense of Bloom's taxonomy see Forehand 2001) for the graduate class, asking for more integration and analysis. The graduate students are asked to read an additional text, Berkes' Sacred Ecology (now the 2012 third edition, originally the 1999 first edition), and choose some of the optional readings to augment required readings. They are also required to post their journal questions online, and respond to other student's posts despite the asynchronous format. This has generated productive and rich exchanges, despite some challenges. The course also includes open discussion forums where students and instructor can share any thoughts or links about the topics of that course section, fostering a "connectionist" approach to learning (Siemens 2005).

As our graduate program is interdisciplinary, students may have little anthropology background, and the majority do not have adequate prior exposure to plant science, though people bring a range of life experience and backgrounds to the course. This can require suggestion of supplemental materials to help make up for deficient background. In terms of prerequisites, Johnson accepts significant cross-cultural experience, or indigenous heritage in lieu of formal anthropology, and sometimes experience in forestry or a personal pursuit of natural history in lieu of academic biology.

As an open university, AU has open enrollment and is dedicated to the removal of barriers to learning. Our distance nature enables us to meet the needs of students living in really remote communities, enabling us to serve people without their having to relocate. Canada is a large and relatively sparsely settled country, particularly away from the southern regions near the USA–Canada border. Our students are very diverse and may have unique local knowledge. Our flexible and student-centered approach to teaching ethnobiology can facilitate their exploration of the nature and implications of their knowledge. For some (e.g., First Nations students with traditional background) our course can be seen as validating their knowledge, and can also extend their knowledge, give perspective on their local environment and cultural settings, and expose them to materials that can enable further growth. (Baptista and El-Hani 2009 make similar points about the multicultural relevance of an ethnobiologically grounded way of teaching biology in a Brazilian high school). The peer sharing that occurs in the graduate course also augments exposure to diverse perspectives, and enables networking of students in very diverse parts of Canada and beyond (see Siemens 2005 for his discussion of "connectionist" approaches to learning in online contexts).

17.4 Conclusion

Our overall goal in our ethnobiology courses is to teach an ethnobiological perspective, one which values both scientific and local (folk or cultural) knowledge and understandings. Our approach is socio-cultural and empirical, but honors diverse epistemologies and understandings. We look for resonances between local and scientific perspectives, and strive to understand places where they are not congruent. We seek to foster a deeper understanding of human relationships to other entities that share our journey—plants, animals, and interrelationships, played out upon the land. We are also interested in process: adaptation, resilience, identity, looking at change, and continuity. We work toward a greater understanding of diverse perspectives toward the living world in an effort to move toward a sustainable and respectful future.

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Chapter 18
Linking Student Skill Building with Public Outreach and Education

Cassandra L. Quave

18.1 Introduction

As educators, we serve the common goal of not only teaching students the core curriculum, but also helping them to develop research and writing skills. Moreover, we aim to cultivate critical thinkers who will one day leave the university as responsible public citizens. Through educating, exciting, and inspiring our students, botany instructors can not only influence the state of plant knowledge in the classroom, but also reach out to improve public awareness concerning various issues of import to the botanical and environmental sciences at large. The aim of this chapter is to explore how botany instructors can bridge the gap from the classroom to the public through teaching students core skills in scientific writing and empowering them to communicate this knowledge to a broad audience.

18.1.1 Fostering an Environment for Critical Thinking

While traditional, standardized assessment methods continue to serve in the important role of measuring student acquisition and basic comprehension of course content, these methods do not account for higher-order thinking and integration of knowledge. On the other hand, authentic assessment techniques, which involve the use of authentic tasks and rubrics, can be very useful in measuring the application of knowledge. This process involves problem solving and critical thinking by the students, and the emphasis here is on the student's ability to demonstrate both the application and use of knowledge (Montgomery 2002).

The importance of authentic assessment is highlighted in the American Association for Advancement of Science (AAAS) and the US National Science Foundation

C. L. Quave (✉)
Department of Dermatology and Center for the Study of Human Health,
Emory University School of Medicine and Emory College of Arts and Sciences,
550 Asbury Circle, Candler Library 107, Atlanta, GA 30322, USA
e-mail: cquave@emory.edu

C. L. Quave (ed.), *Innovative Strategies for Teaching in the Plant Sciences*,
DOI 10.1007/978-1-4939-0422-8_18,

(NSF) *Vision & Change* (V&C) *in Undergraduate Biology Education* document (Brewer and Smith 2011). Specifically, the concept of student engagement in the learning process, with students as active participants rather than passive recipients, is key here. The V&C document also challenges instructors to train students in how to "understand the processes and interdisciplinary nature of science" and to "appreciate the role of science in society and be able to communicate effectively about science with diverse audiences" (Brewer and Smith 2011). The Medicinal Plant Monograph (MPM) project (described below) aims to address these two challenges in the undergraduate classroom.

18.2 Medicinal Plant Monograph Paper Assignment

The MPM project is something that I began in 2010 when I designed and taught an online Medical Botany course for the University of Arkansas at Little Rock Department of Biology. I later expanded upon the project in 2011, when I joined Emory University's Center for the Study of Human Health and began teaching Botanical Medicine and Health in a traditional classroom setting. Thus, this project has been "field tested" in two very different classroom environments—both an online/web-based course and a traditional lecture-based course. In this chapter, I will focus primarily on the implementation of this exercise in a traditional classroom setting, though all pieces are easily adaptable for use in an online course model. In particular, the use of technology such as Blackboard, Camtasia, and YouTube makes this project particularly well adapted for both classroom models.

18.2.1 Providing Structure to the Assignment

The MPM project is broken down into multiple smaller assignments with deadlines distributed throughout the semester in order to make the large amount of work required for a good final product more manageable for students (Table 18.1). Division of the project into smaller tranches has a number of advantages both for the instructor and students:

- Students are less intimidated by the expectations of the project when it is broken down into smaller parts.
- The instructor can provide students with feedback at the different steps, improving the overall quality of the final product and increasing the students' chances of success in receiving a high grade.
- The instructor can work skill-building exercises into the lecture schedule as the various small assignment deadlines approach, helping students to acquire or improve upon important skills (e.g., how to find scientific resources, how to manage and cite references, how to conduct a peer review, how to give a good oral presentation, etc.).

Table 18.1 The plant monograph project is broken down into a series of smaller assignments in order to help students manage the work load and be successful in meeting the learning objectives for the course. This table provides an example of due dates for the assignments during the spring semester, based on a semester start date of January 16 and end date of April 29

Due date	Assignment title	Details
January 25	Choice of plant	Students must post their choice of plant species onto a Blackboard discussion board, selected from a list of acceptable species provided by the instructor. The selection is first come, first served
February 6	Reference list	Students must go to http://www.ncbi.nlm.nih.gov/pubmed to search for 15 references to use when drafting their final paper. Class time (~20 min) is also dedicated to teaching students how to search for and access scientific articles and books using the university library resources
March 4	1st draft	The first, well-written draft of the plant monograph is turned in and redistributed at random to classmates for peer review. Each paper is reviewed by two peers. Class time (~15 min) is dedicated to discussion of peer-review guidelines
March 27	Peer-review reports	Each student must turn in detailed peer-review reports on the papers of two classmates. While the draft itself is not graded by the instructor, the quality of the peer review report is. The reviews are then returned to the authors for use when revising the paper for final submission
April 12	Final paper	The final paper is turned in using the SafeAssign function in Blackboard, which checks for plagiarism
April 17	Slide deck	The PowerPoint slide deck is turned in. The instructor combines all of the submissions into a single PDF, and posts this onto Blackboard for students to use as a study tool and for note taking during the presentation week
April 19–26	Presentations	Students sign up for a time slot (or choice of using Camtasia Studio) for their oral presentations. The free online scheduling site Doodle (http://www.doodle.com/) is useful for this purpose. Depending on the size of the class, four–five class days are reserved for student presentations (10 min each)

As with any other assignment, the key to facilitating student success entails the provision of details concerning the parameters in which they can succeed. Thus, at the beginning of the semester, students are provided not only with detailed instructions concerning both the format and content of their research paper (Appendix 18.1), but they are also provided with the rubrics (Tables 18.2 and 18.3) with which their work will be graded. Moreover, we also spend time in class reviewing these instructions and covering the skill-building exercises mentioned above. The use of scoring rubrics in performance assessment has many benefits, including "increased consistency of scoring, the possibility to facilitate valid judgment of complex competencies, and promotion of learning" (Jonsson and Svingby 2007). As an added benefit, the use of structured rubrics leaves little room for argument concerning grade assignments, and in my own experience, students tend to feel more secure knowing that there are no surprise elements to the instructor's assessment of their work.

Table 18.2 Grading rubric for medicinal plant monograph final paper

Grading criteria	Possible points
Quality of grammar and written English	6
Structure of paper (sections and subsections) follows the formatting instructions	4
Appropriate use of tables	5
Appropriate use of figures (pictures and graphs)	5
Proper formatting of references (APA 6th from Endnote)	4
Citations are appropriately included for information presented throughout the text	8
References come from a variety of sources and the author does not rely too heavily on only a few sources. No websites (other than the USDA database, TROPICOS, Moerman's Native American Ethnobotany database, and Duke's Ethnobotanical Database or the sources of pictures included in the text) are used	10
Quality of the content of individual sections:	
Introduction	12
Botanical description	12
Traditional uses	12
Chemistry and pharmacology	12
Biological activity	12
Clinical studies	12
Contraindications	12
Current uses in allopathic and CAM therapies	12
Discussion	12
Total points	*150*

Table 18.3 Grading rubric for medicinal plant monograph presentation

Grading criteria	Possible points
Presentation follows the required content format and order (addressing the ten slide sections outlined in the instructions)	4
Slides are well organized; use bullet pointed text rather than long sentences	4
Appropriate images are included (i.e., botanical drawings, people using the plant, photographs of the plant and its parts, plant products (commercial or traditional), distribution maps, etc.)	4
Thorough coverage of information in the following key content sections:	
Botanical description	4
Traditional uses	4
Chemistry and pharmacology	4
Biological activity	4
Clinical studies	4
Contraindications	4
Current uses	4
Presenter makes good eye contact with the audience, speaks clearly, shows enthusiasm during presentation, and does not rely heavily on reading notes	5
The central points as to why this plant is important as a medicinal species are clearly conveyed in the overview and reiterated in the conclusion	3
References are used appropriately in the presentation—listing the abbreviated reference or website (for photos) on the relevant slides	2
Total Points	*50*

18.2.2 First Steps to the Assignment

18.2.2.1 The Plant List

At the beginning of the semester, students are provided with a list of medicinal plants to choose from. This spreadsheet includes both the scientific and common names of plants. They are required to post their choice of topic on a first-come, first-served basis using an online discussion board in the Blackboard online platform. Each year, the list is updated so that students do not write their papers on the same plants. This is of particular importance with regards to creation of the e-book (discussed in Sect. 18.2.5). Some basic rules of writing are also covered at this point. Specifically, we review how to format scientific names in class (including rules concerning italicization, capitalization of the genus, use of author epithets, etc.).

18.2.2.2 The Reference List

Following selection of their plant, classroom time (~30 min) is dedicated to teaching the students how to search for appropriate scientific peer-reviewed articles to include in their review paper. Typically, this is accomplished by using the classroom computer and projector to walk the students through a search for resources on some of the different plants that they are working on. Students are provided with a list of websites to use in this search (i.e., pubmed.gov, sciencedirect.com, JSTOR.org, and other in-house library databases). This can also be a good occasion to invite a university librarian or resource specialist to come talk to the class about the literature research resources available to them. Following this exercise, students are tasked with finding at least 15 references to address the various sections of the structured paper. Instructor feedback on this assignment is focused on identifying any gaps in information and suggesting other keywords or databases for students to use in their search. For example, I have found that while students can often find a lot of information on the phytochemistry of a plant, they may have more difficulty in finding resources for basic botanical descriptions of the species or information concerning traditional uses by different cultures.

At this stage in class, we cover how to properly cite a reference resource for both in-text citations and the References Cited section at the end of the document. We also discuss technology options that can facilitate this process. For example, Emory University students can download the reference citation software Endnote (Thomson-Reuters) for free with the university license or use it in the university computer labs. Many students opt to use this or other software options to assist in the streamlined incorporation of references in their papers.

18.2.2.3 The First Draft

Around midsemester, the first draft of the paper is due. While the actual content of the paper is not graded by the instructor at this point, students are expected to have a near-final version of the paper ready. The draft submission is accomplished electronically using the SafeAssign function in Blackboard with the aim of identifying any areas of the paper where the student may have unintentionally (or intentionally) plagiarized (see Sect. 18.2.4 for more on use of this technology resource). This gives them the opportunity to correct any potential issues prior to turning in the final version of the paper. Following submission of the draft, each document is then redistributed at random to two classmates for peer review.

One complication in this process that I regularly face is that at least one person will fail to turn in their draft by the deadline. As waiting for them to turn in a late draft puts unfair time constraints on whoever is assigned the paper for review, I have found that the best solution is to stick to a strict policy of no late submissions being accepted. Thus, for those students that do not turn in their drafts on time, they do not receive peer feedback. Unfortunately, this does put them at a disadvantage in comparison to the students receiving feedback before revising the final paper. To account for the disproportionate number of papers submitted and students required to review papers, other randomly selected student papers will then be reviewed by three peers instead of two.

18.2.3 Peer Review

In addition to being responsible for writing their own review paper, students are also required to complete a peer-review report on two of their classmates' papers. This activity not only benefits the students receiving the review of their work, but also benefits the reviewer. In fact, a number of studies have shown that the peer-review process stimulates both learning and critical thinking (Herrington and Gadman 1991; Liu et al. 2002). Moreover, engagement in a reciprocal review process also boosts recognition of how to improve students' own papers (Palmer and Major 2008). General outcomes of this process that I have observed in the classroom include improvement of the quality and integrity of the final papers, expansion of discussion concerning the science under review, increased knowledge concerning the paper topics by both the paper authors and reviewers, and increased confidence concerning writing skills among students.

Successful implementation of the peer-review process is dependent on the use of clear instructions (Appendix 18.2) and grading rubrics (Table 18.2) for the students to follow. Provision of a structured outline in how to conduct the review helps to teach students how to critique key elements of the manuscript and can serve as a guide for the systematic critical analysis of the work (Palmer and Major 2008). The peer-review criteria used in this exercise are modeled after standard scientific journal reviewer instructions, including the categorization of suggested changes by major, minor, and discretionary revisions. In addition to writing a comments sections in this style, students are also required to use the "track changes" function in Microsoft Word to correct any minor grammatical or spelling errors and "insert comments" to make note of suggested changes to specific sections of the paper. The assignment expectations are that students should go beyond simple copyediting, and rather do research of their own (by reviewing the scientific literature) to provide feedback on the scientific content of the review paper. While students are certainly not expected to write sections of the peer's paper, they are expected to find any major deficiencies in scientific content and provide constructive feedback on this aspect, which might include indications of articles that the peer should read and include in the manuscript citations. With regards to the grading structure for this exercise, the instructor does not grade the draft submissions, but rather the quality and thoroughness of the peer reviews completed by each student. Thus, students also benefit from instructor feedback on their critical analysis process.

18.2.4 Controlling for Plagiarism

Unfortunately, plagiarism continues to be an issue for instructors that include writing assignments in their grading scheme. In some cases, this is done intentionally; there are even websites dedicated to selling "recycled" college papers on common topics to students, whereas other sites advertise unethical services to write essays for a fee (see, e.g., http://www.unemployedprofessors.com/). However, in my experience, most cases have been much less nefarious and more often due to students' lack of understanding concerning the definition of plagiarism. For example, some students will copy a sentence or two from one source, and combine that with something from another source, with the mistaken belief that this is an acceptable means of pulling together "research" for their written assignment. The first step that an instructor should take to prevent this from happening is to dedicate class time to demonstrating to students how to perform a literature search (providing a list of relevant databases and campus library resources to search) with a focus on primary literature sources, reviewing proper citation techniques, and emphasizing the need to write "in their own words" (see Sect. 18.2.2.2).

18.2.4.1 Technological Resources

With the transition that many universities have taken to using Blackboard for online course management (http://www.blackboard.com/), many professors now also have access to "SafeAssign" tools (including *Safe Assignment* and *Direct Submit*) available on the Blackboard platform. These tools streamline the process of checking paper submissions for plagiarism by automatically comparing the submitted paper with an extensive database of published literature, websites, and other previously submitted student papers (from all universities that use this platform). This screen-ing process, in particular, is very useful in identifying paper submissions that have been submitted by a prior student (even if at a different university!). The advantage of this software is that the report provides web links to the original matching content, which allows the instructor to easily investigate whether or not the student copied material from the source. Most submissions may have a hit rate of anywhere from 0 to 20 %. I have found that the References Cited sections of papers tend to artificially elevate the percentage. In most cases, papers with phrase-matching scores of 20 % or less do not indicate plagiarism. As a general rule, I take a closer look at any paper with a score over 20 %.

With regards to other manners of unethical behavior, unfortunately there are no technological resources (that I know of) that can detect whether or not the student bought a new paper from an online service or peer. In this case, the instructor's knowledge of the individual student's writing style and capabilities is still the best resource.

18.2.5 Creating an E-book for Public Outreach and Education

The MPM e-book serves many important purposes in this project. Most relevant to the students at the beginning of the semester, it provides them with examples of successful papers from past semesters and establishes the bar for the quality of the final product that is expected. As we progress through the semester, the meaning of the e-book changes for students as it becomes a point of personal pride for them as evidence of their hard work. Although this is an individual assignment, the fact that they are all contributing to a single end-product gives them a sense of teamwork. Moreover, upon completion of the new edition each semester that the course is taught, many students proudly share the MPM e-book with their family and friends through personal correspondence and social media.

The e-book is publically available year-round online as a PDF document. Although I currently host the file on my personal research website (http://etnobotanica.us/teaching/teaching-materials-and-resources/medicinal-plant-monograph-project), I have also used free online resources such as Google Docs (https://drive.google.com/) to host the file in prior years. The links to the book are updated each semester that the course is taught. In addition to being useful as a static document if printed, the PDF has built-in hyperlinks in the Table of Contents and Index to take the reader directly to the plant profile of interest (listed both under scientific and common names) if viewed on a computer or tablet.

18.3 Student Presentations

The presentation assignment is really just an extension of their final paper. Students do not have to conduct additional research; instead, they are simply presenting the information in a different way. The focus here is on their ability to communicate an interdisciplinary body of knowledge to a broad audience. By the end of the semester, most students are so well acquainted with the details concerning their chosen medicinal plant that the presentation is something that they look forward to as a chance to share their enthusiasm and knowledge with their peers. Moreover, peers are encouraged to engage the presenters both after the talk in a Q&A format and in follow-up discussion boards hosted on Blackboard. The slide decks for each presentation are also posted on Blackboard for students to use them as study tools as they are tested on this material in the final exam.

18.3.1 Providing Structure to the Presentation Assignment

As with the research paper assignment, students are provided with detailed instructions concerning both the format and content of their PowerPoint slide deck (Appendix 18.3) and the rubric (Table 18.3) with which their work will be graded. Moreover, we also spend time in class reviewing these instructions and discussing the "do's and don'ts" of public speaking. Students are encouraged to practice their presentations with peers or friends and even to videotape themselves and watch their performance to improve upon their technique before the presentation day in class.

18.3.2 YouTube as a Public Outreach Tool

YouTube was founded in 2005, and since its introduction has become one of the biggest hosts for online video content and the third most popular site after Google and Facebook (Tan and Pearce 2012). One of the great advantages to using YouTube in the classroom is that both the creation of YouTube accounts and access to video content are free. Moreover, content can be easily shared via social media and even incorporated into learning modules of web-based educational platforms like Blackboard. Another benefit of integrating YouTube in the classroom is the improvement of student engagement in course material (Roodt 2013).

18.3.2.1 Ethnobotany and the Internet

One of the most frustrating things to encounter as an educator specializing in ethnobotany is the abundance of misinformation concerning this science on the Internet. Today's students rely on the web as an educational tool, and when conducting searches on keywords like "ethnobotany" or "medicinal plants," more often than not, links to videos and blogs on psychoactive drugs or advertisements for herbal supplements and "miracle cures" fill the top of the search engine list. It occurred to me that while we may not be able to remove such misleading information from the Internet, perhaps we could "drown it out" by loading more scientific information concerning medicinal plants and ethnobotany in general onto the web. Thus, the TeachEthnobotany YouTube channel (http://www.youtube.com/user/TeachEthnobotany) was created to fill this void in the scientific basis of ethnobotany on the web and to serve as an educational portal for both students and the general public alike.

Since its inception, I have used this platform to post videos of the student MPM PowerPoint presentations that were taped in class or through the use of the screen recording software Camtasia Studio (TechSmith, http://www.techsmith.com/camtasia.html). The use of Camstasia Studio solved two major problems encountered in this process: (1) Some students do not feel comfortable presenting in front of a classroom and/or do not want to be filmed and have their image on the Internet (Camtasia Studio records only their voice over the slides in video format); and (2) there is not enough class time for all students to present in class (I generally reserve four class days for presentations and the rest are submitted as Camstasia Studio recordings). This software was available to the students for free in the computer lab stations at the university, and they also had the option of downloading it to their personal computers for use during its free trial period. This software also allowed for the inclusion of presentations by students enrolled in my web-based course on medical botany, which does not have a traditional classroom setting to accommodate student presentations.

In addition to posting videos of student presentations in the "Medicinal Plant Monograph" playlist on the TeachEthnobotany YouTube channel, I have also created playlists where other educational videos are posted. For example, there is a playlist for:

- Guest speakers who come to present in class and agree to be filmed
- My own lectures created with Camstasia Studio (useful for providing students with a lecture on days that I am away from the university and have to cancel an in-class meeting)
- A selection of favorite videos found on YouTube that meet the scientific and educational prerequisites of the channel
- Interviews with prominent ethnobiologists, recorded at scientific congresses
- Scientific presentations recorded at relevant congresses with the speakers' permission (e.g., Society for Economic Botany and Society of Ethnobiology)
- Other student video projects from my classes taught on the topics of food and health

An important element of managing the channel has been in monitoring comments posted by the video audience. In order to protect the integrity of the channel, all comments must be approved by the moderator (Quave) before being posted on the site. This is to ensure that feedback is constructive and positive, so as not to discourage the students, and to prevent comments that would be highly inappropriate (sexually explicit, profane, or other spam content) from being associated with this educational resource.

These videos have been incredibly useful as supplementary material for my classes. Many of them go to this resource to view short videos on specific medicinal plants that have captured their interest in their reading assignments or lecture. They also use this resource to better understand how to formulate and successfully present their own reports at the end of the semester.

Regarding public use of this educational resource, the number of visitors and subscribers increases on a regular basis. In 2013, just 2 years after its initial launch in July 2011, the channel had 290 subscribers and the collection of videos had been viewed more than 45,000 times by both visitors and subscribers to the channel. Many of the individual student MPM presentations have been viewed several hundred times and a few have even been viewed several thousand times! Knowing that their contribution to the site will influence public understanding of this field has reinforced student dedication and preparation for this project.

18.3.3 Using Social Media

Social media can be an incredibly powerful tool when used strategically to support educational outreach initiatives. People around the world tune in to hugely popular social media platforms like Facebook on a daily basis. Students, likewise, use various social media platforms to stay connected with friends and family. Most relevant to this class, I have found that students who regularly use these platforms are also frequently eager to share their academic accomplishments, and the MPM e-book and YouTube videos provide a simple way for them to do so. The added bonus here is that a wider audience is exposed to lessons in botany with every student that shares their work. Students and the instructor can appreciate that the proverbial "fruits of their labor" can actually have a direct impact on public awareness concerning the plant sciences.

18.4 Conclusions

The MPM project can serve as a robust example of how instructors can utilize technology to (1) improve student competencies in core curriculum material, (2) build a broader skill set in scientific research, writing, and communication, and (3) impact public awareness of botany. The lessons learned here have revealed the importance of using a highly structured model to ensuring student success. The public outreach incentives involved in this process also serve as motivators for students to put their best effort into the project.

18.4.1 Challenges Associated with Project Implementation

Many of the challenges encountered, especially in the initial stages of designing this project, were due to erroneous assumptions made on my part with regards to the students' existing degree of competency in the various skills required for successful completion of this assignment. In fact, for many of the students that I have taught so far, this was the first time that they were required to write a thorough scientific review paper. They needed to be taught how to search for appropriate peer-reviewed scientific literature resources, properly use and cite the resources, give structure to their papers, and present their findings to an audience. However, I quickly found that by breaking down the assignment into many small parts, as discussed in Sect. 18.3, much of the risk for failure on the part of individual students was mitigated and the overall quality of the final papers and presentations was vastly improved.

Students that stay on task with the schedule in this course typically do very well. However, for those who are in the habit of last-minute preparation of assignments or who typically remain disengaged from this and other courses and try to get by through cramming for exams alone do not do well with this model. Unfortunately, I have not found a way to better engage this type of student. However, most students tend to fall in the former category and thrive in this highly structured environment where the expectations and pathway to success are clearly demarcated.

18.4.2 Achievements and Final Remarks

While the implementation of the MPM project does take a considerable amount of effort on the part of both the instructor and students, the end result is something that goes beyond the classroom and that, over time, can impact public awareness concerning topics in botany and the plant sciences at large. Project achievements can be gauged in terms of student performance and public reach. While we do not have any scientific data on how this project has influenced public awareness of the science of medicinal plants, the growing number of subscribers to the YouTube TeachEthnobotany channel and actual number of video views is very promising. A common theme in student evaluations of the course has also been an appreciation of the acquisition of these skills in writing and communicating about interdisciplinary science. As we look to the future of education in the plant sciences, the number and diversity of technologies and educational platforms will surely grow. I believe that creative use of technology in teaching can be highly beneficial to all parties involved, and can contribute to the implementation of new, innovative strategies for teaching and learning in the classroom and beyond.

18.5 Appendix 18.1

Students are provided with the following detailed instructions on how to structure their final paper.

18.5.1 Format of Your Paper

Please follow these instructions very carefully. At the end of this project, the class should be able to produce a set of medicinal plant monographs that adhere to the same formatting and setup.

18.5.1.1 Technical Formatting Guidelines

- Use 11 point Arial font. The entire document should be single spaced and in single column (Dr. Quave will format all final papers to double columns in the final document). The outer margins should be 1″.
- All tables and figures should be placed at the end of the document after the References Cited section. Refer to the tables and/or figures in numerical order throughout the text. For example, Table 1, Table 2…etc.
- Include a description of all tables and legends with the figure or table at the end of the document.
- The monograph should be 3,500–5,000 words in length (not including references). Submission of papers that do not meet the minimum word requirement will result in the deduction of points.
- Download Endnote (free from Emory Software Express) using the link provided in the Monograph folder. Use the APA 6th format style.
- Resources for help with writing are available at the Emory Writing center: http://writingcenter.emory.edu/index.html
- Regarding the scientific name of the plant: Write out the full genus and species name at the beginning of each subsection, and then use the abbreviated genus for the remainder of each subsection. See the current *Medicinal Plant Monograph* e-book for examples.

18.5.2 Headings and Sections for the Paper

Your monograph will be divided into several predetermined sections that must be adhered to. Each section heading will be on a line of its own and highlighted in bold. Subheadings (if any are needed) will be highlighted in bold and italicized.

Genus Species **Author Epithet, Family**
Your Name

Introduction In this section, you should give an introduction to the plant by listing its scientific name and family, common names, and a brief overview of how it is used, what are its main constituents, etc. This should serve as a brief introductory summary about the plant, and the following sections will be used to describe the detailed information.

Botanical Description In this section, you should describe the morphological characteristics of the plant. For example, describe its habit (tree, shrub, herb, etc.), its habitat (marshy areas, arid plains, etc.), its flower and fruit characteristics (color, smell, shape….be detailed in giving a thorough botanical description). What are its relationships with other species? For example, is the pollinator known? You should include a picture of the plant as a figure. Make note of the figure here and place the actual figure (picture) at the end of the document. Remember to cite the source of the figure in the figure legend.

Traditional Uses In addition to writing about ethnomedical uses of the species, there may be some other documented ethnobotanical uses (food, decorative, construction, clothing, etc.). You should mention this here and you may wish to create a subheading for this to separate it from the section on traditional medicinal applications. When discussing traditional medical uses—please specify which culture(s) use this. Do they use it in the same way, or different? How so? How is the remedy prepared traditionally? Is it boiled, or steeped in alcohol? Is it drunk or rubbed on the body? Is the use of this plant documented in ancient texts? Usually, this kind of information can be found in current scientific articles. Has the use changed over time? Is the traditional use relevant to the modern CAM applications?

Chemistry and Pharmacology What are the main known chemical constituents of this plant? If available, also describe the percent in which they occur. You should present this in a table format. You should include images of the chemical structures as a figure at the end of the document.

Biological Activity In this section, you should discuss any *in vitro* and *in vivo* (animal) laboratory studies conducted on extracts or fractions or purified compounds from this species. Is a mechanism of action for the drug's activity known? If not, is there a basic understanding of how it may work? Are there any issues with the development of drug resistance?

Clinical Studies Have any clinical studies been conducted? Specifically, what studies have included tests on human subjects? If so, what were the findings and recommendations?

Contraindications Are there any dangers associated with the use of medicines from this plant? Toxicities? What are they? Have any interactions with other drugs been documented? For example, some drugs interact with grapefruit juice.

Current Use in Allopathic and CAM Therapies Are there any drugs currently on the market that were derived from this plant? This can include over-the-counter or prescription drugs. Were any drugs created by modifying the original plant compound's structure? Are there any herbal supplements on the market based on this plant? How are they sold? What are they marketed as? Is there a recommended dosage for either the prescription form of single compounds or herbal supplement mixtures?

Discussion Summarize your findings. How does this all piece together? Explain why this particular plant has been important to human health and what role do you think it will play in the future of human health.

References Cited Use the APA 6th style for reference citations (selected from drop-down box in Endnote). Do not cite websites (other than the USDA database, TROPICOS, Moerman's Native American Ethnobotany database, and Duke's Ethnobotanical Database or the sources of pictures included in the text) in your paper. Do not cite any of Dr. Quave's lectures. Your paper is to be a thorough review of the scientific literature concerning your plant and should include peer-reviewed journal articles and scientific texts/books.

Tables Give your table a description and title. Tables will be placed at the end of the manuscript. Do not embed them in the main text. Do not cut and paste an image of a table from another source. Create your own table using the information and cite the source(s) appropriately in the table description.

Figures Give your figure a description and title. Figures will be placed at the end of the manuscript. Do not embed them in the main text. Cite the source of the figure in the figure legend. For example: (Source: website address).

18.6 Appendix 18.2

Students are provided with the following detailed guidance on how to conduct peer reviews of student plant monograph papers.

18.6.1 Introduction to Peer Review

Learning how to give a thorough peer review is almost as important as learning how to write a paper yourself. In making a critical assessment of someone else's work, you will often find that the experience helps you to view your own writing in a different way and helps to improve your scientific writing skills. For this exercise, I will randomly select two papers from two of your classmates and email them to you for your review. You have two main tasks when reviewing these papers:

1. Create a peer-review report with comments and constructive criticisms with the goal of helping your classmate improve the manuscript.
2. Make changes to the manuscripts using the "track changes" option under the Tools menu in Word. You should also enter comments into the document by using the "add comment" function. Your classmate can then view the changes and choose whether or not to keep them.

Your peer review of these two papers is worth 50 points (~6% of your final grade), and you will need to take the time to give each paper a thorough review, specifically with regards to the scientific content. This is not just an exercise in copyediting. Take the time to do some literature searches (using http://www.PubMed.gov) of your own to check the validity of the information presented in the monograph. Focus on identifying any gaps in information that should be included. If you feel that the author should incorporate findings from specific studies into their paper, provide them with the name of the paper in your review comments.

18.6.2 Your Peer-Review Report Should Follow the Following Format

1. **Major compulsory revisions** (which the author must respond to before turning in the final version)

2. **Minor essential revisions** (such as missing labels on figures, or the wrong use of a term, which the author can be trusted to correct)
3. **Discretionary revisions** (which are recommendations for improvement but which the author can choose to ignore)

When assessing the work, please consider the following points:

1. Is the grammar and quality of written English acceptable? Please make suggested changes using the track changes function in Word.
2. Does the author adequately address all of the required sections (i.e., introduction, traditional uses, clinical studies, etc.)?
3. Does the author's review seem to be accurate? You will need to do some brief literature searches of your own to verify this.
4. Are figures and tables used appropriately in the paper? Are figure legends included?
5. Is the information reported properly referenced? Please make note of any statements that need to have references added.
6. Is the length of the manuscript appropriate? Are the sections well balanced? Is the content clear and understandable?

Overall, please make detailed suggestions in a constructive manner to help the author improve the manuscript. *Use an encouraging tone in your review*. The goal of this exercise is to help your classmates improve their monographs—*not to discourage or insult them.* At the end of the semester, an electronic book of all of your papers will be made and distributed to all of the authors. This is your opportunity to help improve the overall quality of the e-book. You should also use the criteria in Dr. Quave's final paper grading rubric as a guide when writing your critiques.

18.7 Appendix 18.3

Students are provided with the following detailed guidance on how to structure their class presentations.

18.7.1 Medicinal Plant Monograph Presentation Instructions

All students will give a class presentation on their plant monograph, worth 50 points (~6%) of the final grade. Each presentation and Q&A session must fit within a 10 min time slot. Each presentation will be either videotaped or recorded using Camstasia Studio software for posting on the TeachEthnobotany YouTube channel. This is your chance to shine and educate others on all of the interesting things that you have learned about your chosen plant! Information from the student presentations will also be included in the Final Exam. PDFs of all slide decks will also be posted in the Monograph folder as a study reference.

18.7.2 General Guidelines

- PowerPoint slides must be submitted via the submission link by the deadline posted in Blackboard.
- Use solid colors for the background. Typically a plain white background with dark colored text (black is best) for visibility. Keep the slides crisp and organized. Do not add a lot of special effects as this can make it look cluttered. Do not use special transition effects (such as text that flies in/out) as this is distracting to the viewer.
- Do not include long sentences on your slide; summarize your information with bullet points and verbally expand on the key information.
- You may bring notes up to the podium, but please do not just read from them—use them as a guide instead.
- Dress professionally on the day of your presentation.
- Include source information and references (especially for photos of your plant found online) in smaller print at the bottom of the relevant slide.
- Use the information already compiled in your full plant monograph when creating your slide deck. You should not have to do any extra research when creating this. It is just another way to present the information.
- Practice, practice, practice! Practice giving your presentation to your friends or classmates. Another very helpful way to improve your presentation delivery is to videotape yourself, and then watch how you perform. Pay attention to the amount of time that you spend on each slide, your body movements, and the fluidity of your speech. Never turn your back to the audience to look at the screen. You may wish to watch some presentation training videos on YouTube to get some additional tips. Lastly, do not be nervous about this. Remember that you are presenting to a room of friends and you are going to talk about something that you know a lot about.
- Try to limit the number of slides to no more than 12, and then spend the time on each slide to verbally expand upon and describe the main points in your bullet list.

18.7.3 Number and Type of Slides

Note: this will follow the flow of the sections in your monograph. The goal here is to summarize the monograph info for the class. Use the subheading titles from your monograph as the slide title (in bold here):

1. **Introduction** slide with your plant's full scientific name (including author epithet and family), common English name, and your name. You may also include a picture of the plant or a relevant product here. In this first slide, you should introduce yourself (your name, major, your anticipated graduation year, etc.).
2. **Overview** What is so special about your plant? Tell us what you will be presenting—in other words, set the stage…

3. **Botanical Description** Go over the main botanical characteristics of the plant (pictures are a great addition here). Distribution maps for the growth habitat would also be appropriate.
4. **Traditional Uses** You may need more than one slide to go over this section. This is often one of the most interesting sections. Use it to lead into the chemistry and bioactivity slides.
5. **Chemistry and Pharmacology** This is a great area to showcase the chemical structures of those compounds associated with its activity.
6. **Biological Activity** Review what we know from *in vitro* and *in vivo* (animal) studies. You may include graphs (with appropriate paper citation) if available. This section may require two slides.
7. **Clinical Studies** Review main points of what we know from clinical trials.
8. **Contraindications** Address any dangers associated with the plant.
9. **Current Use in Allopathic and CAM Therapies** How is it used today (outside of traditional practice)? Is it sold in herbal products or supplements? Are chemicals isolated from it included in modern pharmaceutical drugs? Pictures of products would be a nice addition here.
10. **Conclusions** This is the discussion section from the monograph paper. Wrap it all up, tying together what you introduced in the overview. What are the take-home points on this medicinal plant?
11. **References** Include a list of the scientific references cited in the presentation. Citations for figures (usually websites), on the other hand, should go directly under the images on the other slides.

Post any questions about this assignment on the class Blackboard Q&A discussion page so that your classmates can also benefit from further explanations.

References

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