

# THE ROLE OF MOBILE DEVICES FOR CONTEXTUAL LEARNING: PLANT BIODIVERSITY AS A MODEL

## AT Grant FY2009 Final Report

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### 1) Original objectives and strategies, and revisions to same

Our goal was to provide information for students in the learning “moment”, when they were in the field learning about plants. To accomplish this task we began testing the use of handheld computers in three courses, one at UMass Boston and two at UMass Amherst. We also planned to document our experiences on a Wiki but this did not work because most of the discussions were between just between Stevenson and Schoen and in the end the efforts of the group shifted to writing a grant proposal for the CCLI program at NSF (see attachment). We also planned to survey instructors in the UMass System about their use of mobile technologies in teaching. We developed an informational survey see

[http://www.surveymonkey.com/s.aspx?sm=BnvjiSETuSO9o95AWyqW8A\\_3d\\_3d](http://www.surveymonkey.com/s.aspx?sm=BnvjiSETuSO9o95AWyqW8A_3d_3d)

and then thought that it was better to begin by simply identifying educators who are interested in the mobile devices see

[http://www.surveymonkey.com/s.aspx?sm=Ly4StfFb46YGsj01Ev94pw\\_3d\\_3d](http://www.surveymonkey.com/s.aspx?sm=Ly4StfFb46YGsj01Ev94pw_3d_3d)

With help for the UMass system (permission and an email to all instructors with a request to fill out the survey), we still plan to undertake these surveys in a two step process.

### 2) Activities carried out

A. We tried the handhelds in 3 classes as we planned. In each case we now have a product that can be used again in upcoming years. For the non majors evolution class at UMass Boston the initial version of the field guide of common flowers and herbs of the area was not completed in time for the course (there were only 50 species and now we have an 80 species guide to the plants that students most commonly encounter). We are also making a localized guide for the plants on the UMass Boston Campus using the Electronic Field Guide Software and Cybertracker.

#### Amherst activities

Several guided tours of flora found on the UM Amherst campus were developed and tested in classes taught by Karen Searcy and by Sarah McMullen (substituting for Jack Ahern, who was on sabbatical); testing took place in both instructor-led and self-directed tours. Karen Searcy finished three field guides to plants in the Holyoke Range.

B. Rob Stevenson and some of his students visited the Amherst campus 3 times and the Amherst group visited Boston once.

C. We wrote the grant proposal to NSF.

D. We design the surveys to find out about the use of mobile computers in teaching.

3) Deliverables

We can show the online field guides and demonstrate the use of the handhelds

4) Assessment: what can you say about the effectiveness and/or impact of your work, on what bases?

Our focus was to complete the content production for the guides and have 8-10 students try the guides on the handhelds. We were able use the guides as an informal part of the class but delays from technical problems and the small number of units in some case prevented us from making the handhelds a central part of any of the course. We think of what we did as beta testing the procedures, hardware and guides. Informal conversations with instructors and student were critical but generally favorable. People like the idea of the handhelds

5) Issues and further questions raised by your work - things you'd like to investigate further or would leave for others

A. From our experiences with this project and from Stevenson's experiences using the iPhone, it is very clear that mobile technology has a place in field courses and that smart phones are going to be an important avenue for educational support and instruction. (See attached list of three articles from Education Week and Teacher Magazine.) The ease with which information can be accessed with smart phones is really astounding.

B. Do you know of a venue or/and funding mechanism that would help us develop ideas with our colleagues across the five campuses (we might also included colleagues from the community colleges)? We think there are opportunities for external funding.

6) Disposition of funds. Please note the expectation that any unexpended funds will be returned to the President's Office.

All the funds have been spent.

7) Any other comments you'd like to make - **including your assessment of the grant program itself**

The funding provided was the key to increasing the collaboration between the campuses. Without the funding we would not have written the CCLI proposal to NSF. We have enough hardware now to try the approach in the coming years. As the cell phone revolution comes this experience should put us ahead of the curve.

Please email your report, preferably as a PDF, to Carol Ryan (cryan@umassonline.net). I (Mark) shall be out of the country and pretty much offline between June 9 and June 16. If in that time period you have questions, please contact Carol.

Also, several of you have asked about presenting your work. While it will be on a smaller scale than the Instructional Technology Conferences of the past few years, the SAT plans to hold an event in the fall which we hope will afford you the opportunity to share your experience. We'll update you on that during the summer, as details take shape.

On behalf of the Subcommittee on Academic Technology and the President's Office, let us again thank you for your efforts to enhance teaching and learning at UMass.

Best wishes,

Marlowe Miller, Mark Schlesinger, and Carol Ryan  
for the Subcommittee on Academic Technology

# 1. Introduction- Seeing the Forest and the Trees

Emily is finishing up her Biology honors thesis, a survey of wildflowers found at disturbed and old growth sites in the Holyoke Range of Western Massachusetts. She is reviewing her thesis materials, which she has archived on her Field Studies website: the numerous photographs and scanned drawings, descriptive text, data tables and maps, all complete with metadata. As she works, Emily reflects on the process that got her to this point. A year ago, she had only the vaguest idea of how to identify plants, and certainly could not have identified 250+ species by sight. She had always enjoyed field trips, but in the past, once a course was finished, little of the experience persisted in a tangible form. In her first botany course with Dr. Searcy she learned how to “see” landscapes, plants, and plant characters. She learned what important morphological characters were, how to use a botanical key, how to take a scientifically useful photograph of a plant and how to add metadata. She remembered her surprise when Kiara had posted a picture of a *Trillium* via *Twitter* and then texted her while they collected data. Kiara was hoping Keith, the TA who was making an *Electronic Field Guide* for the region, would use her picture as part of his project and get Kiara two bonus points. Next Emily had taken an environmental studies course in Costa Rica with Professor Dumont. They used digital archives on the Field Study site to learn about tropical trees, lianas, and herbs before their trip, and managed their data on the same website while in Costa Rica. Emily had become proficient with *Google Earth* and KML files. Along with her expertise in habitat and plant ID, this made doing her thesis a snap. Once her committee accepted her thesis, the document and all her data would become publicly available on the website. For Emily, the creation of a public resource would be deeply satisfying. Even more important, the process of learning how to observe, record, collaborate and communicate had hooked her on pursuing a career in conservation and botany.

Field courses are an integral part of undergraduate science study (McKenzie et al. 1986, Rudolph 1996, Janovy and Major 2009) and a critical and often highly enjoyable activity for students studying environmental sciences (Elkins and Elkins 2007, but see Yore and Boyer 1997). Students yearn for the outdoors environment and love the hands on opportunities. Some who struggle in the classroom excel out of doors. Field trips are often the most memorable part of a course. In addition to just being outside, traveling together produces an informal atmosphere that can improve communications within the group. The formality of the classroom is abandoned and a new intimacy and new social connections ensue (but see Anderson et al. 2008).[There are many more papers on field studies for K-12 students; see Falk et al. 1978, Krepel and DuVall 1981, Martin et al. 1981, Falk 1983, Orion and Hofstein 1991, Orion and Hofstein 1994, Bogner 1998, Rickinson et al. 2004, Lindemann-Matthies 2005, Dillion et al. 2006, Lindemann\_Matthies 2006, Farmer and al. 2007, Rahman and Spafford 2009 . The general conclusions are in line with the previous statements but these papers offer a more in depth view.]

The primary focus of this proposal is to develop a framework using new information and communication technologies to improve field courses and examine the utility of this framework in four courses that study plants. This first section identifies two specific goals and outlines how communications technologies are contributing to the teaching of science. The following sections describe our plan to apply this framework for teaching about plants in four different courses.

Our first specific goal is to find better ways to teach students how to see and turn their observations into knowledge (Table 1). A second teaching goal is to improve the ways students communicate their observations among themselves, their instructors and with the wider world. This second goal is usually not a significant part of course curricula but it models what scientists do and it leads to students becoming practicing scientists, either formally or informally.

## **General Teaching Goals for Field Studies**

### **Improve the way we teach people to see**

Seeing (or “observing”) is fundamental to doing science. The more we see, the more we understand. This leads to more questions and wondering. We begin to synthesize patterns and identify anomalies. The famous evolutionary biologist Ernst Mayer told a high school biology teacher, “The most important thing we can teach our young people is to observe well.” (Leslie and Roth 1998. p. 157). The challenge of teaching people how to see has an important “chicken and egg” characteristic. We need to ratchet up our observation skills and knowledge together, as the following quotation from Miall (1896, p.1-2) notes:

“The earth seems still, and cold, and dead. Yet there are living things hidden everywhere around. This morning my boys found a live caterpillar of the Yellow Underwing, lying helpless on the snow, driven out, perhaps, from its underground retreat by the cold. The experienced collector can find plenty of pupae, even in the depth of winter. A keen eye is wanted to distinguish them, for their colouring is strongly imitative, and their retreats carefully chosen. Nor will keen eyes suffice unless there is knowledge also. *“Man sieht nur was man weiss,”* says Goethe, and the insect-hunter verifies the saying. The trained naturalist goes about in the winter, and sees living things everywhere. The eager, but uninstructed naturalist can hardly find anything.”

Our first essential question is “How do people see?” Visual learning, as characterized by the passage from Miall’s book, is a paradoxical process because to see, you have to know and to know, you have to see (Note that Vision Science is extremely large and active field of research; see Palmer 1999 for instance. We are appealing here to the general sense: how making observations with guidance and attention can help people become better observers). Our visual system is constantly working to make sense of the visual world. To any vision task, we bring visual knowledge that lets us recognize patterns. We can rapidly decode basic aspects such as shape, size, color, and movement. When something “catches” our eye, output from our visual system connects with our knowledge schema. A “catch my eye” reaction also indicates we are wondering about the object. This leads us to search for more information. We concentrate our attention on the “object” to discern more about what we see. We research the literature and seek out other viewpoints to help us make sense of what we have observed. With practice, we refine our observation skills, learning to separate significant detail from irrelevant background. We eventually develop the ability to consciously evaluate what we observe. This process connects seeing to knowing, and as we go back and forth between seeing and comparing our observation with our own internal or external logic and knowledge, we **ratchet up** our understanding (Table 1, Goal I, Essential Understandings A). Another essential understanding is the connection between form and process or structure and function (Goal I, Essential Understandings C). When an initial observation is revisited and reflected upon over time, deeper understandings emerge. When training people to think scientifically we want them to learn to consciously engage in this process.

### **Teaching modern methods of communicating observations**

The first requirement for communication is for people to record information in the most objective way possible (Table 1, Goal II, Essential Understandings A). When seated in front of an apple tree in winter and asked to draw it, elementary school children will add leaves and bright red apples even though the tree is bare (S. Speak, personal communication). Their background knowledge is interfering with their observing. It was not until the 16<sup>th</sup> and 17<sup>th</sup> century that a tradition of realism in drawing developed in natural history studies (Ivins 1969, Freedberg 2002). The goal of minimally biased observations is central to science. As the observer’s content knowledge increases, descriptions contain more technical and scientific language. Scientific language is developed to be more specific and accurate but is a barrier for non-experts.

Table 1. Teaching Goals for Field Studies

Essential Understandings	Assessment
<i>Goal I. How to see</i>	
A. Ratcheting process of seeing and knowing	Document stepwise advancements in seeing and understanding using student interviews and journal entries.
B. Visual focusing	Interview students about their ability to focus and evaluate while observing
C. Recognizing the relationship of form/structure to function/process	Determine whether the student is learning to observe as experts do
<i>Goal II. How to synthesize and communicate observations</i>	
A. Objective scientific observer - describing what you "see"	Analyze student journals for their factual content, thoroughness and use of scientific language.
B. Contextualize observations with metadata	Compare the metadata provided by students with scientific standards for the metadata.
C. Classmates share perspectives what is observed (peer review)	Analyze individual and group student journals for evidence of exchange of ideas and revised documents
D. Publish in public domain	Measure the media forms and the number and richness of data files published on websites

Second, to communicate observations effectively, the observations must be placed in context (Table 1, Goal II, Essential Understandings B). A drawing of a lilac shrub in blossom becomes useful for phenology studies if the metadata about this drawing (e.g., time-date, location, observer, etc.) are also known. There are a number of metadata standards that are helpful for field observations in biology (see TDWG web site) and photographic standards (Hauser et al 2005, Baskauf and Kirchoff 2009) and often less than a dozen types of observations (e.g. Darwin Core), are enough to make them very valuable.

The third component of communicating observations involves selecting, ordering and synthesizing the information into a coherent story (Table 1, Goal II, Essential Understandings C). Drafting and revising, whether in the arts or sciences, is advanced with the help of peers and consulting experts. Selecting the best picture, verifying an identification, or checking to see if a description says what you want it to say, is best done with the help of other people. In science this is often a two-step process in which lab partners and friends offer their comments and advice, followed by a formal review by anonymous reviewers that is orchestrated by publishers.

Finally, participation in science is not complete until the observations are shared with the broader community (Table 1, Goal D). Traditionally sharing has been in the form of journal articles, but the advent of the Internet has put new emphasis on sharing data. Taxonomists are making digitized records of historical museum specimens available on-line and ecologists are sharing their much more heterogeneous data on the web (Wilson 2003). For field studies, data has traditionally taken the form of notes, counts and drawings. Often specimens are collected and observed or tested in the lab. Bits of information collected over time and space allow field workers to produce synthetic views of ecological processes. Publishing on the Internet is now common and relatively easy.

### ***Technology in Support of Field Studies***

Astounding advances in communications technologies are revolutionizing the way our society functions and changing the way scientists work in the field (Stevenson et al. 2003, Wilson 2003, Gaston and O'Neil 2004, Agarwal et al. 2006, Khanafiah and Sittungkir 2006, White et al. 2006, Yu et al. 2006, Kwok

Table 2. Ways that technologies can be used to improve field courses

Mobile Technology Impact	Technology Example
1. Image-based technologies can advance visual literacy.	Images across spatial scales from satellite to micrographs can be linked using <i>GigaPan</i>
2. Real time positioning and mapping can help with safety, orientation, and spatial literacy	GPS technologies are now widely use to aid people navigating in the field
3. Information delivery systems can be customized for time and place and learner knowledge	Customized mobile tours in the field, alert user to local points of interest
4. Information delivery systems can allow people to bring more resources to the field	Digital 3-D Maps, site-specific <i>Electronic Field Guides</i>
5. Electronic collection of data leads to better documentation and earlier and easier archiving	Digital photographs for e-vouchers, handhelds geo-tag data as it is collected
6. Social networking technologies can advance collaborative learning and production skills	<i>Facebook, Twitter, Wiki, Flickr</i>
7. Communication via mobile devices are highly engaging to students	Cell phones and Wi-Fi Devices

2009). Most teenagers and college students are significantly better at programming phones, using social networking sites and other web-based technologies than are their parents or their college instructors. Adoption of these technologies for science education has lagged (Johnson et al. 2009, p. 6), but offer they offer advantages (Table 2, Borgman et al. 2008) that we will harness in this project and that many others are experimenting with (Grant 1993, Abowd et al. 1997, Parr et al. 2002, Tinker et al. 2002, Chen 2003, Cheng 2003, Herrington and Herrington 2006, Bressler and Kahr-Hojland 2007, Avraamidou 2008, Avraamidou et al. 2008, Herrington et al. 2008, Stocker and Burke 2009). A significant challenge for us has been ascertaining which software and hardware technologies can best advance our teaching goals. By and large we view the technologies as tools to improve our teaching and better prepare the students as scientists. Experience has taught us that too much effort placed in the technology development reduces the time for core teaching (Cheng and Lane-Cummings 2003). If a technology is unknown to the students then a coordinated effort is needed to make the technology more than a toy. In various places we discuss these tradeoffs. The consensus is that as cell phone devices or similar devices come closer to the ideal field studies tool, we will understand what role they can play for enhancing our teaching.

## 2. Field studies on Plants – A two year pilot study

**Pilot Study Expectations:** The goals described in Table 1 provide a framework for the transformation of field studies. A complete evaluation of the framework of Table 1 is beyond the scope of this proposal, yet we think it is essential to guiding our activities. Successful testing of the goals of Table 1 requires that several critical components are in place; 1) well annotated and illustrated digital catalogs of habitat, plant and plant characteristics, 2) seamless interaction of software solutions and tasks described in Table 2, and 3) Hardware (e.g.. GPS unit, digital camera, smart phone) that can run the necessary software, in the possession of students and professors with the skill to use it. (Some phones such as the iPhone come close to this functionality now.) Given that the elements necessary to complete this vision are not yet in place, what progress can be expected in this pilot study? In the next section we outline what progress we have made to date and then describe both shared and individual goals of the four courses. Practical implementation requires us to keep an eye on emerging mobile technologies even as we employ currently available software solutions to meet our goals.

**Courses:** We propose to use the framework outlined in Table 1 to direct changes in instruction in four courses at UMass Amherst and UMass Boston (Table 3). These courses share a focus on plants for a significant part of the semester but span a range of disciplines, class sizes and student knowledge, student botanical and field experience, and student commitment. Students in Searcy's upper division botany class

are likely to have the most experience and interest, while students in Stevenson’s class are likely to have the least because they are non majors there to fulfill a science requirement.

Table 3. Courses at UMass campuses used to examine the SFT goals.

Instructor	Campus	Department	Course Title	Student Composition	Class Size
Jack Ahern	Amherst	Landscape Architecture and Regional Planning	Envir. Design 335: Plants in the Landscape	Landscape majors, So. –Sr.	130-150
Betsy Dumont	Amherst	Biology	Bio 497H Tropical Field Biology	Honors, Jr - Sr.	25
Karen Searcy	Amherst	Biology	Bio 426 Botany	Bio Majors, Jr. -G,	25
Rob Stevenson	Boston	Biology	Bio 102 Evolution	Non Majors, Fr. - Sr	80

### 3. Previous NSF Support

PI Elizabeth Dumont: IOS-0447616 (2005-2008, Dumont, P.I., I.R. Grosse, co-P.I.): The goal of this collaborative, interdisciplinary project was to translate methods and analytical approaches that originated in the engineering domain and apply them to the analysis of complex three dimensional (3-D) problems in comparative biology. Specifically, we use finite element analysis (FEA) to investigate the relationship between loads imposed by feeding and skull shape in mammals. This work placed us on the crest of a rising wave of research that uses finite element (FE) modeling and analysis to address fundamental questions in biomechanics, ecological morphology and evolutionary biology. Through this grant we developed FE models for our own research and guided the development of 24 additional models for collaborators and students from other universities. We have published five papers and presented our results via invited symposia and platform presentations at eight national and international meetings. This grant allowed us to offer cross-disciplinary training in biology and engineering to 12 UMass students. Of these, half were female and one was Hispanic. In order to share the techniques we developed with the emerging generation of scientists, we also provided significant guidance and training to five PhD students from US institutions and one undergraduate from the University of Antwerp.

DBI-0743460 (2008-2012, Dumont, P.I.): Finite element analysis (FEA) is a computer-based technique for predicting the physical behavior of engineered products based on fundamental equilibrium principles of mechanics. FEA revolutionized engineering and has the ability to do the same for biology by transforming the way we approach problems in areas ranging from functional morphology to development and evolution. For this transformation to be revolutionary, it is critical to develop a freely available collection of finite element models, associated metadata, and analysis tools, which is the goal of this new grant project. During the past year we have made progress toward this goal by establishing and populating a website, hosting a “Finite Element Modeling in Biology” workshop, and developing 10 finite element models. This project has supported two graduate students and one undergraduate (REU) student and generated one publication.

Co-PI Robert Stevenson: NSF DBI 0416835 Electronic Field Guides: Building Partnerships and Informatics Tools for Species Identification and Biodiversity Monitoring 09/01/2004-08/31/2007, Robert A. Morris, PI, Robert D. Stevenson, Co-PI, \$1,020,365.00. The project (EFG 2008) extended previous work on Electronic Field Guides to provide an open source, robust, and easy to use framework for the generation of EFGs from data provided by authors in spreadsheets or in commonly used databases. Authors provide character data, polytomous keys, and multimedia files, such as images, sounds, or videos, principally using spreadsheets, which the software transforms into a MySQL database. Interactive Web forms then support the provision of appropriate metadata, and user interfaces are configured using templates from a library. Once configured, the framework generates a web service representing database-backed identification tools and species accounts. Our principal advance was the achievement of our

earliest and primary goal: to provide a system by which biologists can produce sophisticated field guides with little or no assistance from computer scientists or software engineers, in ways that can participate in the growing body of interoperable biodiversity information software. To date, ten authors have deployed 30 field guides, oriented both taxonomically and thematically, and in some cases embedded multiple EFG products in general guides to the biota of a region (EFG 2008). We have four more being currently being developed on ants, shells, mammals and shrubs.

## 4. Progress To Date

There has been interchange and collaboration among the PIs for several years and support from two grants: NSF DBI 0416835 grant titled “Electronic Field Guides: Building Partnerships and Informatics Tools for Species Identification and Biodiversity Monitoring” described above and a University of Massachusetts Academic Technology grant titled “The Role Of Mobile Devices For Contextual Learning: Plant Biodiversity as a Model” Robert D Stevenson, PI, Jerry Schoen Co-PI. This project, like the current proposal, involved collaboration between the UMass Amherst based Water Resources Research Center (WRRC), which supports research, education, and outreach on water resources issues, and the Center for Educational Software Development (CESD), which designs, develops and deploys advanced computer-based instructional systems, on-line educational content and interactive multimedia. Other collaborations include an environmental education project for middle school students using similar technology.

These grants have allowed us to compile digital content for the courses and experiment with hardware (digital cameras and handheld computers with GPS) and software that would be used in the SFT project. We have worked together and with computer scientists.

The NSF grant has allowed us to make *Electronic Field Guides (EFGs)* of plants found in Amherst, Boston and Costa Rica (where Dumont’s class will study). Dr. Searcy has assembled guides of Flora for the Holyoke Range. Under Dr. Stevenson’s management there are EFGs for Invasive Plants of Nantucket, Bogs and Acidic Fens of Southern New England, Flora of the Boston Nature Center, and the Trees and Wildflowers of Plum Island (EFG 2009). These guides can be viewed on a computer or mobile phone over the internet or used to make laminated picture guides. In the second grant we experimented with providing information about plants in the learning “moment”. Professor Ahern assembled digital images, text and audio clips about the trees found in the Amherst Arboretum. We used Hewlett Packard’s *Mscape* on ASUS 626 and ASUS 639 handheld computers to help students learn about the arboretum trees for self-guided field trips and research excursions. The *Mscape*<sup>1</sup> program uses the ASUS’s GPS function to alert students to the proximity of specific trees along the tour and display related content as the students approach. Nine students in Stevenson’s class used *CyberTracker*<sup>2</sup> to record observations at their student sites. Students said they liked being able to find plants using several search methods such as life form, flower color, and leaf shape in *CyberTracker*, but found the application needed more than 50 species to be useful. Stevenson is now revising the version to include more species. We are experimenting with making high-resolution panoramic images with the aid of a recently purchased *GigaPan*<sup>3</sup> device (See below).

## 5. Teaching to See Habitats, Plants, and Plant Characteristics

All courses (Table 3) share a common goal of teaching students how to see or observe plants and recognize their structures. Traditionally students learn about plants by hearing lectures, sorting plants into groups, drawing plants, using keys for plant identification, and making collections. In the SFT project, we

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<sup>1</sup> *Mscape* associates physical locations with digital media, which are loaded onto a GPS-enabled mobile device and triggered by proximity to the “hot spots,” creating an interactive “Mediascape.”

<sup>2</sup> *Cybertracker*, running on a mobile device, helps to identify specimens using a dichotomous key system, and logs observation data, which can be exported and shared.

<sup>3</sup> The *Gigapan* system combines hardware, software and a photo sharing website to enable the creation of high quality panoramic photos, which can be viewed on the site of used in other applications.

propose a model that complements these traditional approaches by concentrating on how technology can improve observation and communication skills.

We start by assessing how students see plants (Tull 1994, Barman et al. 2006). Depending on the class, this may involve using descriptive, labeling and drawing assignments, followed by demonstration and discussion of the phenomenon of Plant Blindness (Wandersee and Schussler 1999, Wandersee and Schussler 2001, Hershey 2002, Wandersee et al. 2006). Students may test themselves on their sensory and hemispheric preferences (Sousa 2005), and demonstrate and discuss how visual attention matures. We plan to apply an online assessment tool developed by Marc Poplun's lab at UMass Boston called *JEyeTracker*, that asks students to compare images of one target with 4 images. A blurring technique limits what can be seen; one can then move the mouse to clarify parts of the image. We can compare that identification accuracy with information about where the students moved the mouse to unblur the image.

### ***Habitat, Plant and Leaves: Seeing across Spatial Scales***

Practically everyone nowadays has used the scalable digital maps found on numerous web sites to find a restaurant, get directions to a relative's house, or tag along on your roommate's summer vacation photo journal. Review exercises with these maps will prepare students to navigate in the field and to locate, describe and characterize their study sites. In addition, the maps will form the starting point for talking about scale in a biological sense. To make the connection between aerial photographs and individual plants, some classes will use a new technology called *GigaPan* that makes panoramic images that can be readily linked to aerial maps. A *GigaPan* photograph is taken by use of a robotic assembly that attaches to a camera and tripod and succession takes multiple sequential images of a scene. Post-trip, *GigaPan* software stitches the photographs into a highly detailed panorama. A *GigaPan* image can be uploaded onto *Google Earth* and anchored onto the landscape in a way that allows a user to virtually fly from on high right "into" a photograph. Once there, the zoom feature allows a close view of detailed landscape features. By linking *GigaPans* and *Google Earth*, and nesting two or more *GigaPans* within another, one can stretch scale from global to minute. We will use *Google Earth* and *GigaPans* to simulate these bird's and bug's eye views of botany for students. We will apply *JEyeTracker* software to *GigaPans*, monitoring how students see scale by tracking their movements across these images.



Example of *GigaPan* used to study meadow flora. Actual image can be enlarged 10 – 50X this size.



Detail of apple tree from the *GigaPan*



Detail from second *GigaPan*

Second *GigaPan* can be taken of outlined area.

## ***Bringing the Library to the Forest***

How do naturalists prepare for a field trip? Commonly, they study or review species likely to be encountered. They assemble maps, collecting materials, notebooks and an assortment of field guides to match the scope of their inquiry, the size of their backpacks, and the physical shape they're in. With today's digital technologies, you can fit all this in your pocket (Parr et al. 2002, Stevenson et al. 2003, Chen et al. 2003, Agarwal et al. 2006). We are experimenting with several applications that function as the field biologist's personal librarian. To date we've found: 1) For the beginning botanist, mobile guided tours are an excellent means of carrying the lessons on seeing plants into the field. 2) As students begin to acquire the knack of seeing plants, *Electronic Field Guides (EFGs)* are a good way to bring them to the next step of learning to identify specimens. We will employ different versions of the guided tours and EFGs in several of the courses taught in the SFT project.

## **6. Communicating Our Observations**

### ***Course Descriptions and Requirements***

Jack Ahern's **Environmental Design 335: Plants in the Landscape** students are required to keep notebooks in which they record observations throughout the semester. They draw, take notes; some insert digital photographs. The majority of their observations are of flora on the UMass Amherst campus. The notebooks, which are graded, are primarily intended as a resource for the students themselves, to be kept and referred to in future courses and professional work. Professor Ahern is interested in students using **multimedia journaling** for these notebooks. He believes that digital products may improve the quality of students' work, enhance their learning, and benefit the broader community. As curator of the campus Arboretum, Professor Ahern thinks digital output from student notebooks can contribute to an online Arboretum guide that would enhance community engagement with an awareness of the Arboretum.

Elizabeth Dumont's **Honors 497H: Tropical Field Biology** is an upper-level honors course designed to provide students with hands-on experience designing and carrying out field-based projects. The course is divided into three distinct parts. During the first half of the semester students attend lectures on tropical biology and ecology, and learn about sampling strategies, population estimation, and plant and animal identification. Working independently with faculty mentors, students design their own field projects. The second portion is a 10 day trip to Costa Rica to conduct fieldwork. Here the students collect field data with the guidance of their faculty mentors. Most of the remainder of the semester is devoted to students presenting the results of their research projects to one another and working independently to write up the results. Approximately 20% of the students enrolled in the course choose to complete a project on plants. In the past these have ranged from studies of the spatial distribution of species or age cohorts, to comparisons of taxonomic diversity in different habitats, or studies of plant-animal interactions. Professor Dumont's students will use *CyberTracker* to record digital data on fruiting and flowering phenology, plant distributions in light gaps and pollination observations.

Karen Searcy's **Bio 426: New England Flora** is a classic botany course with the objective of learning the common plants of the local flora. It combines indoor classes where the students focus on learning vocabulary, keying, major groups of plants and common families, and field trips where students observe plants and learn about their ecology and natural history. *CyberTracker* or *Mscope* can be used to provide detailed images of species we will be seeing on some of the field trips. These images can be annotated and posted on a class website providing an on-line study guide. Electronic Field Guides may also be a way to engage students on fieldtrips. Finally, in place of traditional plant collection, students can make digital photograph collections, either on field trips or on their own. Students can be asked to respond to a series of questions designed to help them observe the plants in context. The photographs and associated responses can be posted, using social networking tools or multimedia journaling.

Rob Stevenson's **Bio 102: Evolution** is a non-major's at course UMass Boston, in which students engage in field observations through the study of plants for about half of the fall semester. How to make

observations on flowers and fruits, describe a study site, document the reproductive output of a plant species (seed production and plant density) and identify plants to compile a species list are modeled with demonstrations and walks on campus. Students select a study site that is convenient for their own observations. UMass Boston has an urban commuter population; a wide variety of sites up to 80 miles from Boston are selected. The students compile a list of at least 30 plant species. Currently their species list is verified by submitting pressed plants or prints of digital photographs. The data for the class are compiled and we look at the proportion of species that are native, introduced and invasive across the spatial extent of study sites. *CyberTracker* will be a good solution for students to ID and record observations in the field, with students documenting their species list via a collection of digital images.

## **Multimedia Journaling**

The ideal multimedia journaling tool consists of a single device that records sound, video, photographs, text or dictated notes, taxonomic and related list information, time- and location-stamps every data point recorded, regardless of format, and seamlessly integrates this information when back in the lab with data sets obtained in previous field trips and/or by other researchers. To our knowledge, a good working device does not yet exist (Yen-wen and 2005, GreenHill and Venkatesh 2008). While we await its appearance, the SFT project will work with existing hardware and software tools, some of which are of our own design, to mimic the perfect device's functionality.

Digital photography will be a primary method of data collection for students in all SFT courses. Putting into practice what they were taught about seeing plants, students will photograph flora at a variety of ranges, from the plant part to landscape-level assemblages. The correct photograph can be a powerful verification tool, enhancing quality control for any observations made (Monk and Baker 2000, White et al. 2006, Belhumeur et al. 2008). Because digital photos are so transportable and replicable, they become a more widely accessible part of the record. And they may well reveal more information than the written record they were meant to verify. The written record reveals only what the author thought or knew to specify. In some respects, a photograph may prove a truer representation of the observed phenomena. Shown this photograph, an entomologist might double the species count documented by the botanist photographer<sup>4</sup>.



The scientific or educational value of a photograph is often greatly increased when its location, time and date are known. Species distribution, landscape change, phenology, spatial and temporal trends all become clearer with this additional information in a data collection. Time stamps are automatically collected with digital photographs. To our knowledge there is no widely available, error free system of automatic locational data capture for photographs. However we will teach students to geo-locate their photos by either of two methods: 1) Take a GPS reading along with the photograph. 2) Estimate the location, if known. In either case, students will use any of several free or shareware software tools (e.g. *GeoSetter*, *GraphicConverter*) that geo-tag the images, either by entering latitude and longitude coordinates directly (e.g. from the GPS readout) or by pinpointing the location on a digital map.

Students will write or dictate (using the camera's sound recorder) notes on associated observations and metadata (e.g. number of specimens seen, life stage, tentative ID, etc.). Some students will also draw in paper notebooks. These collected data points are then brought back to the lab for further processing.

Three of the courses will use data collection routines developed in *CyberTracker*, a location-aware field data recording application, specifically for each course. While still not the perfect multimedia field journal, it does take a step in that direction by combining several important data collection functions.

## **The Social Component: Peer Help and Peer Review**

Rather than let observations slumber in private journals, students will revisit them in online discussions. Students process their collected field data in individual and shared virtual workspaces. To

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<sup>4</sup> That's a stonefly in the iris.

facilitate this, we will build a multimedia platform that combines functions of photo sharing, mapping, and electronic discussion forums (i.e. social networking sites). Our long-term goal is a networked communication system that perfectly integrates these functions in a way that is easy to use, that students find engaging, and that promotes collaborative learning. In this 2-year pilot, we will evaluate existing software applications such as *Flickr* (photo sharing), *Google Earth* (mapping) and *Facebook* (networking). At a minimum, we will develop a web site that hosts all three (or comparable alternatives). Students will establish “placebook” pages on *Facebook*, devoted to a particular study site or a particular project. Students will sign on as “friends” of each other’s sites/projects. They will store their photos in similar *Flickr* groups, which they link back to *Facebook* and to *Google Earth*. This will allow them to move the conversations back and forth between text, photo galleries and maps of their study sites. Based on previous experience, we know this system as described will work, imperfect as the linkages may be. Once we perfect the system, all these will work as one integrated process that will enhance the flow of information, images and ideas among classmates.

Students will use this networked communication system in several ways. Using social tagging software, they can collaboratively catalogue observations and assembled products (e.g. reports, compilations of multiple observations, bookmarked URLs, special purpose maps), providing a student-centered data organization and searching scheme. Because the content is location-stamped, *Google Earth* affords students another, visually oriented spatial search method; students will be able to see what other students are working on in nearby sites or similar habitats. The collective knowledge and experience of the class as a whole emerges as a learning aid. Students can compare their own photo-documented species IDs with those of their classmates, and review and correct their own work as advisable. They can seek and offer advice to their peers, and pool material and ideas with team members sharing an assignment.

This system will also include a discussion forum dedicated to technology issues: students can request help on any problems they have working with hardware and software, give their views on how useful these tools are as educational aids, or offer suggestions on other tools or other ways of using the tools that might be useful. This portion of the forum will be open to all members of all classes, and to all faculty and staff partners in the SFT.

## ***Digital collections***

All the instructors have either a requirement or a potential use for students to make digital collections of plant photographs. There are many options to record images (cell phones, pocket cameras, SLRs) and to edit them (*Adobe Photoshop*, *GIMP*, *IRFanView*, *Picasa*, *Microsoft PhotoEditor*, etc). These software are available at public computer labs on both UMass campuses. For the most part we will let the students take responsibility for this step. We will make suggestions about how to solve digital imaging acquisition and editing problems and provide links to web resources. We will make recommendations to the students about how and what photographs to take (Baskauf and Kirchoff. 2009, Häuser et al 2005) options for adding metadata (GBIF has a draft metadata standard for multimedia resources and *Flickr* EoL (*Encyclopedia of life*) group, has tagging instructions to make images available from *Flickr*). In each course, we will present students an overview of the issues involved in data archiving and required data elements. They will learn of the compromises involved in employing easy archiving protocols that promote widespread participation in data collection and preservation efforts vs. more stringent requirements that can produce archives with more robust, but fewer data records. Of the several options available for sharing images we think our current best option is to use *Flickr* (we have investigated and used *Picasa* and *Menalto Gallery*). *Flickr* seems to have the best combination of easy web-access, facilities to add metadata including geolocation, options for defining groups and ability to interact with other software. We envision that images can be shared within the class and with larger audience. We are exploring options to archive data and images in the scientific databases *Specify* and *Morphbank*.

## ***Publish Observations***

Digital media offer many alternatives to traditional publishing methods, from tweets to blogs to Wikis to photo sharing sites and *Google Earth* layers. A variety of these will be explored in the individual courses. We will emphasize “stories of place” in all courses, and teach the use of KML (XML-based language schema for geographic data) to publish place stories. The geo-tagged images, text, species lists and completed maps that students produce all tell a story about a given place. In whatever format, and whether that story is intended for private use (e.g. as a diary, or personal species distribution map) or for public consumption, inserting place into the story enriches it with additional context and perspective.

We will teach students to use KML to publish their output; KML offers an easy way to wrap a series of images and text into a story that is associated with a particular place. By virtue of the ease in which KML files can then be linked with one another, emailed, uploaded and downloaded from web sites, and inserted into a wide variety of mapping and other software applications, the place story itself becomes highly portable. For example, a user might physically go to a location to experience the story “on scene” on a PDA, or may visit the site virtually via a *Google Earth* session. We believe these technologies are ushering in a new era of spatial literacy, and we want our students to be early innovators in that era.

## **7. Management Plan and Technical support**

Betsy Dumont is PI and is responsible for the project overall. Jerry Schoen is Project Manager, and will coordinate all activities across groups, courses and campuses. Rob Stevenson is PI for the Boston campus, working with Dumont and Schoen. In addition to the course instructors, the project has support from CESD and WRRRC at UMass Amherst, and from the CS department at UMass Boston. Matthew Mattingly, CESD Multimedia Director, will oversee the technical team, who will develop, test and deploy system, train all instructors and TAs, and help to coordinate access across multiple campuses. Evaluators will report to Schoen and through him to Dumont.

**Project Management/Collaboration:** CESD will establish a project wiki or discussion site to facilitate group communication and collaboration. Group will meet monthly or more frequently by phone, in person, and/or electronic chat. Meetings will include demonstrations of works in progress and products in development. Evaluators will attend monthly meetings. In early meetings, project partners will agree on general specifications for IT tools to use in field, class, lab and student homework for plant ID classes. CESD will (in consultation with UMass Boston on the *Electronic Field Guide* and *CyberTracker*) develop generic versions of each, designed to work with flora. The group will also agree on general principles for: features desired for student social networking; metadata and database structures needed to prepare student output for publication; ways to accommodate each course’s content, level, students, and technological resources; and how training and support will be provided for each class: for instructors and students.

**Curricular Integration:** We recognize that the above principles are likely to require some modification to meet specific needs of each class. For each course, starting one semester in advance, CESD will meet with instructors of each class to identify course-specific needs, based on subject matter, course objectives, students’ comfort with technology etc. Also taken into account will be existing materials such as photos and data, collaboration possibilities to prepare new content, course meeting times, due dates, etc. CESD will work with relevant faculty to develop the specific *Mscope*, *EFG* and *CyberTracker* or other templates to be used in each class, and to identify and address any targeted data repositories and output formats requiring custom attention for the class. CESD will coordinate ongoing support for these tools during semester of use. This will include training with the hardware and software tools as well as administrative functions such as keeping track of the loaned equipment. WRRRC will serve as liaison with local experts, project partners, et al. WRRRC and CESD will continue research on emerging technologies throughout the project period.

**Deployment of IT Equipment:** We have conducted a hardware resource / needs assessment for the SFT. Ahern’s and Stevenson’s courses, totaling approximately 200 students, are taught in the fall

semesters. Dumont's and Searcy's courses, (total 50 students) are taught in the spring. Combining requested hardware from this grant with on-hand hardware, we will have 38 GPS-enabled PDAs and 40 digital cameras, and 2 *GigaPan* setups. One *GigaPan* setup per campus will suffice; with an occasional, supervised exception for special projects, students will not need to use *GigaPan* hardware. The smaller spring semester classes can be accommodated with this inventory. The larger classes will use a combination of our equipment and students' own cameras and PDAs. We are making an assumption that by 2010 at least 30% of students will own digital cameras and at least 10% will own GPS-enabled cell phones or PDAs. The rapid rate of adoption of ever more capable mobile technology by students gives us confidence that, assuming teams of 2 for cameras and teams of 3 for PDAs, full coverage will be achievable by fall 2010, when the first large classes will take place. Part of our evaluation process will be to keep current with emerging technologies running on popular platforms such as the iPhone, and adopting these as appropriate. We recognize that a significant challenge when implementing a program of this nature is the support and management of hardware. If units are loaned out, they need to be tracked and maintained; if students are required to use their personal equipment, then software tools must be compatible and CESD support staff must be familiar with a range of platforms. Finding optimal solutions to these challenges will be a major part of our development process.

## 8. Key Personnel

**Elizabeth Dumont** will serve as Principal Investigator for this project. She is an Associate Professor of Biology and Director of the Natural History Collections at UMass Amherst, where she has been since 2001. Dr. Dumont's research focuses on the morphology and evolution of mammals. Specifically, her strongly interdisciplinary research program addresses feeding in mammals using techniques that range from analyses of feeding behavior and performance in the field to detailed /in silico/ 3D modeling of stress/strain in the skulls of mammals in the lab. She has extensive field experience in both the Paleo and Neotropics and has taught a Tropical Field Biology course for undergraduate for eight years. Dr. Dumont also teaches Mammalogy and was awarded a Lilly Teaching Fellowship in 2006. In addition to serving as PI, she will provide content expertise and implement the system in her courses in spring 2010 and 2011. (See Table 3 for course listings.)

**Robert Stevenson Ph.D. (Co-PI)**; Assoc. Professor of Biology, Univ. of Massachusetts Boston has degrees in Engineering and Biology and has been collaborating with Robert Morris of the UMass Boston Computer Science Dept. for over ten years on the development of the *Electronic Field Guide* suite of authoring tools. He has participated in NSF sponsored projects to produce standards for Ecoinformatics, served as vice chair of the Informal Science committee of the National Ecological Observation Network Design team, is co-PI at UMass Boston of the grant to develop the Center Coastal Environmental Sensor Networks. Stevenson is Co-PI on this project and will coordinate activities at UMB, oversee EFG development, and also implement the system in his courses in fall 2010 and 2011.

**Jerry Schoen, M.S.**, is the founder and director of the Massachusetts Water Watch Partnership and the Massachusetts Stormwater Technology Evaluation projects at the WRRC. He has worked on water quality and citizen science issues since 1990, and on use of information technology for formal and informal science education and research applications since 2003. Named UMass Extension Technology Fellow 2003. Played lead role in conceiving, securing \$500,000 (5 year) Department of Education 21st Century Community Learning Center Program funding for, and hiring coordinator of Athol Middle School eQuest program (2007-8). Currently managing the UMass subcontracted role in the EPA-funded Tri State Connecticut River Targeted Watershed Initiative. Managing the Massachusetts Stormwater Technology Evaluation Project under contract with Massachusetts Department of Environmental Protection and US EPA, 2004- present. Organized and ran the Massachusetts Citizen Monitoring Technical Service Provider program under contract with the Massachusetts Office of Environmental Affairs (EOEA), 2000-2003; Under contract with EOEA, authored three manuals on quality assurance project plans, one on data presentation, several on water quality monitoring. Schoen will be the Project Manager, coordinating activities on both campuses.

**Matthew Mattingly** is the Multimedia Director of CESD, where he works with faculty and other experts to design and specify interactive multimedia materials for education, and with programmers and artists to develop prototypes and finished products. CESD creates online educational modules and websites employing graphics, animation, video, and interactive learning objects, addressing diverse topics in the sciences and humanities, including Art History, Astronomy, Classic, Economics, Entomology, Genetics, Nutrition and Psychology. Mattingly will oversee the technical team at UMass Amherst.

**Jack Ahern**, Ph.D., FASLA. Professor Ahern holds a Bachelors degree in Environmental Design (University of Massachusetts), a Masters in Landscape Architecture (University of Pennsylvania), and a Ph.D. in Environmental Sciences (Wageningen University, the Netherlands). He has been on the faculty of the Department of Landscape Architecture and Regional Planning at the University of Massachusetts at Amherst for 19 years, currently serving as professor and Department Head. He is a Fellow of the American Society of Landscape Architects (1996). He received a Fulbright Award for teaching and research in Portugal (1997), where he worked on applied landscape ecology and greenways. Ahern will provide content expertise and implement the system in his courses in fall 2010 and 2011.

**Karen Searcy**, PhD is Lecturer in the Biology Department at UMass Amherst and is Curator of the University of Massachusetts Herbarium. Her research interests are focused on rare plant species. Recent projects include a flora of Fort Devens, location of rare species and exemplary communities on Metropolitan District Commission land in the Quabbin and Wachusett Reservations, community survey of Satan's Kingdom wildlife management area and assisting in a biological survey of Lake Rohunta. Currently she is working on a flora and vegetation analysis of the Mount Holyoke Range, Massachusetts. Searcy will provide content expertise and implement the system in her courses in spring 2010 and 2011. (

## 8. Evaluation

Evaluation of this project will be led by Drs. Alan Peterfreund and Kenneth Rath of SageFox Consulting Group. Since 1999 they have served as evaluators for numerous FIPSE- and NSF-sponsored projects involving educational innovations and pipeline programs at several institutions nationwide. Among these have been a number of projects with CESD around the Online Web-based Learning (OWL) system in a number of disciplines.

The evaluation efforts will focus on both formative and summative information. For the first, we will collect formative feedback from the students and instructors regarding the use of the various program components, providing the team with material to guide their efforts to improve and refine the products. For the second, we will assess the increase in student skills as a function of using the developed materials.

The formative evaluation will be accomplished through student end-of-course surveys and interviews with the course instructors. Both groups, in all four courses, will be asked to provide feedback on the extent to which the impacts outlined in Table 2 have been reached. They will also be asked to provide their general impressions about the developed materials, how useful they were, how easy they were to use, and how the materials might be improved or better integrated into the courses.

The focus of the summative evaluation, however, will be on one course, Jack Ahearn's course on Plants in the Landscape. This course was chosen because there are enough students in the course to have some statistical validity to the findings, unlike the courses taught by Betsy Dumont and Karen Searcy, and because Rob Stevenson's course, while otherwise ideal, will be taught by a different instructor in 2009, thus not providing the opportunity for a good comparison group.

The evaluation will focus on measuring the skill outcomes outlined in Table 1. Student notebooks will be collected, starting with the class in the fall of 2009, prior to project start, again in the fall of 2010, and then again in 2011. The skills evidenced by the students in these notebooks will be rated based on a rubric developed by the evaluators, the course instructor, and the project team, and scoring will be done blindly, by scorers who do not know the students. The first scoring will be done in 2010, and at that time the scorers will not know what semester the notebook they are scoring came from either, thus preventing bias from tainting the findings—this, of course, will not be done for the 2011 data since we will have already analyzed the data from the previous two years.

Part of the purpose of this rubric-based metric for analyzing student skills is to develop a protocol wherein the products can be evaluated as they are disseminated to other classes. To this end, we will also examine notebooks from students in the other classes, but these will not have a group from a pre-materials semester to look at as a comparison.

The evaluators will prepare annual Evaluation Reports documenting their findings for inclusion in the PIs' annual NSF reports.

## 9. Broader Impacts

The framework we are developing (Table 1) is tailored to undergraduate sciences field courses, including integrated semester-long expeditionary experiences and courses at field stations. The ideas and approaches, however, have relevance to a much wider audience and in venues far beyond the pure and applied college courses, including education curricula in K-12 schools, in adult education programs and for informal science teaching. The benefits of taking students outside are widely recognized (Janovy and Major 2009).

The work we are doing has relevance to Citizen Science programs. Citizen Science is practiced by individuals and institutions at universities and science museums across the globe. Central to these efforts is the ability to easily and accurately identify objects in nature and to share data with fellow citizens.

At both campuses instructors have ongoing partnerships with nature centers (UMass Boston with the Massachusetts Audubon Society's Boston Nature Center which serves a minority population in a suburb of Boston and UMass Amherst with the Mills River Environmental Center which serves a rural population in Athol, MA.) Instructors from each campus are already conducting two one-day workshops with students and environmental instructors at these centers to evaluate the usefulness of the instructional technology for populations other than college students. Faculty at UMass Boston are also evaluating the technology with Boston Public School students doing studies on the Boston Harbor Islands and with groups of graduate students and middle school teachers in their WISP GK-12 Program.

Another major connection of this proposal to university education is the use of mobile computing devices, identified along with geocoded data as "technologies to watch" in *The Horizon Report* (Johnson et al 2009). The revolution in communications across the globe is evolving at a torrid pace and many people in education are adapting cell phone and social networking technologies for use in their teaching. This is because these forms of communication are coming to dominate our social lives and work environments and because they offer new, more participatory teaching opportunities. We will also survey our fellow instructors across the campuses of the University of Massachusetts system about their experiences, ideas and attitudes towards using mobile technologies for teaching. We will share what we are learning from our courses and surveys on a public website called [MobileTechnologiesForTeachingFieldCourses](#). We plan to share our experiences in teaching and teaching technology in forums throughout the university system.

## 10. Phase II

The focus of the Phase I proposal is exploring the broad ideas of seeing and communicating natural phenomena observations (Table 1). After Phase I, we will have a better understanding of how students can successfully develop visual attention and identification skills as applied to plants. A natural extension is to broaden the content area. Preliminary talks with our colleagues suggest that our approach can be extended to other courses in Forestry and Anthropology departments. Our team has already identified Entomology courses on both campuses as another venue to examine the SFT idea. The course instructors will continue to develop a pedagogy about "seeing" and to develop text and multimedia content that can be used for a variety of the applications.

A second goal relates to communicating observations within the class and with the broader world using the WWW and mobile technologies. While few would quibble with the broad vision we have expressed about the rapid advances in communications, we agree that there is great uncertainty about the

particular applications and hardware that will support our education goals. For now we will continue our research and experimentation to identify the best solutions. With time, we anticipate a broader range of consumer products that can be employed to support our scientific communication goals. Our general strategy is to actively separate context from specific technologies. On one hand we are trying to leverage students' knowledge, experience and access to mobile technologies and apply it to field studies about plants. Other the other hand we want to teach the students fundamental concepts from environmental informatics regarding metadata and place based studies.

## 11. Timeline and Milestones

PERIOD	ACTIVITY TYPE	TASKS
<b>Jan-June 2010</b>	System Development	Select, obtain hardware, software, supplies for project pilot phase. Select photo and social networking sites. Set up accounts, linkages and tag sets in selected sites  Set up project wiki, build MobileTechnologiesForTeachingFieldCourses website
	Testing	Test system components for reliability, usability and accessibility
	Evaluation	Define standard assessment tools – review digital libraries of habitat, plant and plant characteristics. Instructors agree on pre- and post-assessment tools for all classes, that will measure knowledge about / experience with field biology, plant ID and the academic use of information technologies.
<b>July-Aug 2010</b>	Prep for fall courses	Seminar for instructors by informatics/IT team on tools, procedures and metadata used to create a digital image (multimedia) collection. Seminar for instructors on use of <i>GigaPan</i> images for instruction. TA training on system, integration with grading, etc.
	System Development	Obtain content, build course specific instances of <i>Mscape</i> , <i>CyberTracker</i> , <i>EFG</i> , etc., program PDAs, configure web sites.
<b>Sept-Dec 2010</b>	Implement in fall courses	Support system implementation in courses. Configure distribute equipment
	Spring Courses Prep	Obtain content, build course specific instances of <i>Mscape</i> , <i>CyberTracker</i> , <i>EFG</i> , etc., program PDAs, configure web sites.
	Evaluation	Evaluators prepare first year report
<b>Jan-Feb 2011</b>	Revisions	Project team reviews fall evaluation data, revises system for spring courses.
	System Development	Continue to refine system, continue content work as needed
	Continue prep for spring courses	Seminar for instructors on tools etc. TA training on system, integration with grading, etc.
<b>Feb-June 2011</b>	Implement in spring courses	Support implementation of system in courses. Configure, distribute equipment
	System Development	Continue to refine system
	Evaluation	Evaluators collect data, surveys, etc.
<b>July-Aug 2011</b>	Revise system	Final tweaks to system based on spring course feedback
	Revise fall courses	Changes to content and tools as needed
<b>Sept-Dec 2011</b>	Support fall courses	Support use of system in courses. Configure, distribute equipment
	Evaluation	Evaluators prepare final evaluation report
	Final report	Write and submit final report