

Advancing Integration of Museums into Undergraduate Education: AIM-UP!
Program Evaluation
By Anna K. Monfils
Central Michigan University
30 April 2016

NSF0956129

Joseph A. Cook, Scott V. Edwards, Stefanie M. Ickert-Bond, and Eileen A. Lacey,

Summative Evaluation:

This is a summative external evaluation for the Advancing Integration of Museums into Undergraduate Education: AIM-UP! This is a National Science Foundation (NSF) sponsored project through the Research Coordination Network (RCN) on the targeted track in Undergraduate Biology Education (UBE). This program supports the means by which investigators can share information and ideas, coordinate ongoing or planned research activities, foster synthesis and new collaborations, develop community standards, and in other ways advance science and education through communication and sharing of ideas.

This evaluation is being conducted by Dr. Anna K. Monfils, associate professor and Director of the Central Michigan University Herbarium, in the Department of Biology at Central Michigan University. The report will include a broad description of the project as completed, the stated goals of the project, an introduction to assessment instruments, a detailed discussion of the products of the RCN-UBE (including outcomes, challenges and on-going initiatives), and a brief summary.

Project Description:

AIM- UP! is a network intended to explore and produce new ways of incorporating the extensive archives and cyberinfrastructure of natural history museums into undergraduate education under 5 primary themes: 1) *Integrative Inventories: Exploring Complex Biotic Associations Across Space and Time*, 2) *CoEvolution: Art and Biology*, 3) *Generating Genotypes: Evolutionary Dynamics of Genomes*, 4) *Fast Forward: Biotic Response to Climate Change*, 5) *The Human Dimension of Natural History: Emerging Pathogens, Invasive Species, Loss of Biodiversity and other Societal Challenges*. AIM-UP! sought to enhance existing efforts and develop new integrated approaches to collections-based training in large-scale questions using the combined and broadly-based expertise of educators, curators, collection managers, database managers, and scientists whose teaching and investigations span across various disciplines and relate to topics covering a wide spectrum of time and space. Networking activities included five annual two-day "all-hands" working meetings, regional thematic meetings, workshops and presentations at scientific meetings, and an annual fall semester seminar course (available via webcasting). Materials detailing AIM-UP! participants, activities, and project outcomes can be accessed at aimup.unm.edu

Goals of Project:

- a. Facilitating discussion among undergraduate educators, curators, collection managers, database managers, scientists, and others (artists, federal resource managers) about new possibilities in specimen-based education.
- b. Creating a broadly-based and diverse network of individuals whose teaching and investigations span across various disciplines and relate to topics in biology that cover a wide spectrum of time and space.
- c. Identifying novel approaches to the use of natural history collections in undergraduate training.
- d. Developing prototypes for those novel approaches to the use of collections in undergraduate training.
- e. Implementing outreach efforts targeted especially to underrepresented students with an emphasis on issues relevant to their communities (e.g., Native communities in the Southwest or bush Alaska).

This project had a no cost extension into a sixth year and thus spans the time period from 5/2010 to 4/2016.

Assessment:

Throughout the project, efforts were made to conduct both formative and evaluative assessments.

Meeting Questionnaires

Pre- and post-meeting questionnaires were completed for the "all-hands" annual meetings starting in 2012 and for the regional Flagstaff, Arizona 2014 meeting. Meetings evaluated include:

- Fairbanks – February 2012 (15 pre-meeting, 17 post-meeting)
- Cambridge – April 2013 (13 pre-meeting, 12 post-meeting)
- Asilomar – March 2014 (21 pre-meeting, 9 post-meeting)
- Flagstaff - August 2014 (8 pre-meeting, 8 post-meeting)
- Sevilleta - January 2015 (9 pre-meeting)

Results from pre-tests were formative and shaped the meeting discussion. Post-tests from the yearly meetings were evaluative and formative; responses provided yearly assessments of network development and were used to craft agendas and plan effective meetings in subsequent years. Post-meeting questionnaires were not completed for the Sevilleta, New Mexico 2015 meetings. The pre- and post-meeting questions and responses can be found in Appendix I.

Workshop Responses

A feedback summary form from the Association of Science-Technology Centers workshop in 2013 (26 attendees, one summary response) and survey and responses from the American Society of Mammalogists workshop (N=51) are in Appendix II.

Program Evaluation Survey

A program evaluation survey was designed to evaluate the success of the AIM-UP! RCN-UBE at achieving program goals, determine the next steps in promoting the use natural history collections and associated data in undergraduate education, and discern the next steps in sustaining the network. The survey was developed in collaboration with AIM-UP! (PI Joe Cook), Shari Ellis (iDigBio) and Anna Monfils (Program Evaluator) and received IRB approval (protocol # 16U0125). The survey was sent to a large segment of the participants in the network (N=115). The survey and responses (N=57) are in Appendix III

Student surveys and University of New Mexico course evaluations were conducted for module implementation and seminar courses. These materials were numerous, but did not inform the RCN-UBE efforts as implemented. They are not included here.

RCN-UBE Products

Website

Starting in year one, a website was developed for the project. This was maintained and updated throughout the project. Initially at aim-up.org, the website went through an overhaul in 2014 and content was transferred to aimup.unm.edu. The revised website is visually appealing, logically organized and information is easier to retrieve. The AIM-UP! Website provides details on the RCN and effectively archives information about annual meetings, participants, and affiliated museums and networks. Citations and/or abstracts for national and international presentations and publications resulting from the RCN-UBE are provided with links when available. New educational materials and content are delivered in the form of videos and AIM-UP! modules. This website effectively centralizes resources for education and natural history collections.

The website, and the efficacy of the website at delivering content and community building, were not assessed. Usage statistics are not available. There was some confusion accessing the website as both the older and updated versions were live for much of the granting period (it is now fixed). In the *Program Evaluation Survey*, participants were directed to the revised website to see web deliverable materials. The issue with two active websites was noted and one participant suggested the addition keywords or tags to make the modules more searchable. When asked about why participants had not used one or more of the modules, several noted they were not available when needed (6/35) or were unaware they existed (5/35). As is the case with many grants, products often occur near the end of the grant. This is true of the website content, as much of the material did not reach deliverable status in time to implement or disseminate within the grant timeframe.

The website is the public face of the network and can function as a centralizing hub in the growing AIM-UP! network. The website has the potential to be a clearing house for

information on incorporating natural history collections into undergraduate education and would benefit from further development (e.g., organization, keywords, additional links). Moving forward the AIM-UP! website needs to be actively and consistently maintained; a dedicated Webmaster is recommended to keep things current and address organizational issues that plague any website as it grows (e.g., redundancy, ease in searching, dead links). In future iterations of the web presence, it would be valuable to gather usage statistics, these data can be valuable for the community as we look to quantify impact of collections on education. In the absence of funds, maintaining the website will be a challenge but is critical to deliver materials and maintain a presence to grow the community.

Annual Meetings

Five annual "all-hands" meetings were held over the course of the grant. These meetings brought members of the community together to refine educational themes, develop teaching methodologies, demonstrate existing modules, facilitate cross-institutional training efforts, develop and evaluate instructional activities, and integrate other biological disciplines into museum-based training. Annual meetings served to centralize the activities of the group, facilitate new collaborations and build a larger, inclusive network of museum professionals and educators.

Year I: The RCN hosted a meeting in Santa Fe, New Mexico 14-16 October 2010. This meeting was attended by 22 individuals (with 1 participating remotely), representing 14 institutions, departments, or agencies. During the meeting, attendees discussed all the objectives of the RCN, formed questions to be addressed, and developed a plan to address those questions. Committees were created and charged with specific goals and tasks. A format for the yearly fall seminar course was developed. Participants discussed and developed goals for evaluation of RCN activities. A website to establish a web presence was planned and launched with development of content a major goal of the next year.

Year II: The RCN hosted a meeting in Fairbanks, Alaska 20-22 February 2012. This meeting was attended by 25 individuals, representing 15 institutions, departments, or agencies. Eighteen of the participants were new to the network. During the meeting, attendees discussed module development for lectures and laboratory activities, Implementation of recommendations in *Vision and Change*, and challenges associated with engaging students. Four module ideas were introduced and module working groups were initiated. Module topics were Biodiversity Assessment, Climate Change, Assembling a Flora, and Tree Thinking. Module working groups were developed. Standardized module expectations, evaluation plans, and student surveys were initiated.

Year III: The RCN hosted a meeting in Cambridge, Massachusetts 11-13 April 2013. This meeting was attended by 21 individuals, representing 13 institutions, departments, or agencies. Sixteen of the participants were new to the network.

During the meeting, attendees discussed dissemination of information about the AIM-UP! RCN-UBE including an AIM-UP! *BioScience* manuscript, workshops at meetings, and module publication. Existing modules were discussed with break-out sessions to further develop modules that included natural history collection specimens and genetics/genomics.

Year IV: The RCN hosted a meeting in Asilomar, California, 26 February -2 March 2014. This meeting was attended by 24 individuals, representing 17 institutions, departments, or agencies. Nine of the participants were new to the network. During the meeting, attendees discussed a potential climate change modules, bioinformatics and big data, sequential modules, potential publication/s, and network evaluation. Break-out sessions were conducted to further refine a set of standardized module components, to develop assessments of student knowledge about natural history collections, and discuss the challenge of integrating new curricular materials that would be scientifically and pedagogically valid. The group addressed challenges with dissemination of modules and potential next steps for the network.

Year V: The RCN hosted a meeting at the Sevilleta LTER, New Mexico, 22-25 January 2015. This meeting was attended by 25 individuals, representing 16 institutions, departments, or agencies. Twelve of the participants were new to the network. During the meeting, attendees discussed human dimensions and museums, updates on existing efforts (students in collections, surveys, participant projects), evaluation of existing modules, and participant projects. Break-out sessions were conducted to look at "human dimensions" module development, video development, and next steps for the network. The group outlined some potential next steps for building the network and potential next steps when the grant is complete.

The yearly "all-hands" meetings were a key factor in establishing and growing the network. The AIM-UP! Network grew rapidly, exceeding its goal of three new members a year in every year of the grant. The yearly meetings were instrumental in creating a sense of community and participants became vested in seeing the network grow and be productive. The open discussion, presentations, and working groups brought together a diverse group of educators, collection and database managers, and scientists. Seventy-eight participants (45 male/33 female; 29% underrepresented minority) from 42 separate institutions, departments, or agencies attended at least one meeting. The inclusion of representatives from different disciplines, research strengths and institution types (Community Colleges, Tribal Colleges, Minority Serving Institutions, 4-year primarily undergraduate institutions, and research universities) resulted in a broadly based and diverse network. Annual meetings were effective in developing and empowering participants to become educational nodes in the AIM-UP! network and extended the reach and inclusivity of the group.

In the *Program Evaluation Survey*, 71% (39/55) of respondents had participated in at least one annual "all-hands" meetings. When all AIM-UP! participants were asked, "What was most effective at building a network?" Many respondents (14/27) indicated annual meetings were a pivotal component of building the network. When asked, "What were the biggest challenges?" respondents made particular note (10/28) of the challenge in maintaining momentum on projects and ideas after the meetings. A few comments from the *Program Evaluation Survey* respondents indicate a frustrated desire to become more involved. This is a good indication that members of the community want to continue to grow the network.

There is a strong sense of community among the AIM-UP! participants. The yearly meetings served to strengthen developing relationships that crossed disciplines, institutions, and research interests. AIM-UP! developed alongside the national digitization efforts (iDigBio & ADBC) and has benefitted from the developing infrastructure related to specimen digitization. In the absence of annual meetings, participants will have to make more deliberate efforts to promote museums in undergraduate education. A possible step would "piggy-backing" educational workshops on national discipline (Botany and Mammalogy) and cross discipline meetings (e.g. SPNHC, Society for Systematic Biology, Evolution, Ecology). This would allow for face-to-face meetings with minimal cost. In the absence of funds, this will be difficult to sustain and will rely on participants to drive the program without a professional reward structure.

A limitation of the invited meeting is that interested collections community members required an invitation to participate. Without any doubt, the AIM-UP! RCN-UBE made every effort to be inclusive. Annual meetings were well attended. By necessity, these were limited in size. Future community building would benefit from an open venue. This would flush members of the community who are just now becoming aware of or able to participate in AIM-UP! efforts.

The invited meeting module is not sustainable, new initiatives related to module development would benefit from building on the existing community and need to maintain the tie to AIM-UP! strengthening nodes and continuing to build on the momentum. Currently funded NSF programs provide opportunities for collection community members to develop and modify new and existing modules; a future step would be to continue to ally AIM-UP! efforts with existing resources (i.e., BioQuest.org, QUBES, iDigBio). Current efforts to create a Faculty Mentoring Network through QUBES (and with the support of iDigBio and the Biodiversity Collections Network RCN) are promising.

To sustain efforts related to community building and continue to modify, disseminate and implement modules using natural history collections data, the AIM-UP! community needs to expand and accelerate momentum. To grow and sustain the AIM-UP! community, and continue ongoing initiatives, it is imperative to reach out to and

integrate efforts across emerging educational efforts from TCNs and through iDigBio, via education groups at national meetings (e.g., education committees for ESA and BSA national societies), and by partnering with educational initiatives at complementary organizations (e.g. Esri, KURATOR, Animal Diversity Web).

Regional Thematic Meetings

Five regional and/or thematic meetings were held over the course of the grant. These meetings brought smaller groups of AIM-UP! participants together to conduct specific hands on workshops, complete module development, frame and write manuscripts for submission, and vision future directions for the network. These meeting provided an opportunity for highly motivated participants to create products and accelerate the momentum of the building network.

Natural History Collections, Art & Ecology, Sevilleta LTER, New Mexico, 20-21 December 2011: This was a two day retreat (eight participants) to discuss how to incorporate natural history collections into environmental history courses, geography, ecology, art, and the Honor's Program (game development).

AIM-UP! Cedar Key Retreat, Cedar Key, Florida, 2-4 May 2014: This was a three-day retreat (seven participants; six institutions, and two new to the network) to discuss plans for the future of AIM-UP! and Climate Change Education manuscript development.

AIM-UP! Flagstaff Meeting, Flagstaff, Arizona, 14-16 August 2014: This was a three day meeting (nine participants; seven institutions, and seven new to the network) to investigate incorporating natural history collections into indigenous education. The group explored ways that specimens might be used in biology courses with an emphasis on place-based lessons.

AIM-UP! San Jose Meeting, San Jose, California, 4-6 October 2014: This was a three day meeting (9 participants and seven institutions) Following the Life Discovery – Doing Science Education Conference, sponsored by the Ecological Society, Evolution Society and others. A small AIM-UP! working group met and focused on detailing future AIM-UP! initiatives. Topics covered included potential themes and angles for a new RCN UBE (small collections, increased pedagogical expertise), status of surveys (to be launched in next month), module development, action plan for climate change education manuscript, potential for co-sponsorship of education workshop at 2015 Florida SPNHC meeting, and potential activities and themes for January 2015 All-Hands meeting at the Sevilleta Field-station in New Mexico.

AIM-UP! Chicago Meeting, Chicago, Illinois, 11-14 February 2016: This was a two day meeting (5 participants (1 virtual), five institutions) to discuss the status of incorporating natural history collections into undergraduate education. The group discussed a manuscript detailing how natural history collections have been

incorporated into undergraduate education, next steps for the community, a survey of AIM-UP!, providing materials to textbook authors incorporating natural history collection data, and a workshop to further develop and disseminate AIM-UP! modules.

Small groups meetings were conducive to product completion and assisted in maintaining momentum for motivated participants. The regional thematic meetings were effective at organizing ideas, developing modules, planning upcoming meetings, brainstorming publications, and creating group consensus on next steps. In the *Program Evaluation Survey*, 25% (12/48) of respondents had participated in at least one regional or thematic meeting and four of the 27 respondents to the questions, "What was most effective in building the network?" specifically referenced the thematic meetings. These smaller theme based meetings maintained momentum as the RCN-UBE neared completion and facilitated concrete discussion of next steps.

Outcomes directly related to Regional Thematic Meetings include:

- Two manuscripts (Cook *et al.* 2014, and Lacey *et al.* 2016 *in review*)
- Two manuscripts *in prep* from the Flagstaff 2014 and Chicago 2016 meetings
- A funded proposal to iDigBio for a 2017 workshop based on AIM-UP! module development and dissemination, titled "Building and Disseminating Resources for Collections-Based Undergraduate Education."
- An accepted abstract to participate as session presenters for *Lowering the Activation Energy - Quantitative Biology Summer Institute 2016*. Abstract titled "Creating a Faculty Based Network for Incorporating Digitized Natural History Collections Data into the Classroom."

Small meetings serve to sustain the motivation of the highly invested participants, but encounter the same problems as large meetings in terms of sustainability. The members of the community motivated to participate need to be provided an outlet for productivity. Such an outlet may be through virtual communities that can meet to achieve tasks. The QUBES Faculty Mentoring Networks is an excellent way for AIM-UP! participants to continue efforts to develop modules and work in focused groups. Participants wishing to pursue these endeavors are self-selecting and motivated. Success of a Faculty Mentoring Network would speak well of the success of AIM-UP! in empowering the community to integrate education into undergraduate courses.

Modules

A primary goal of the RCN-UBE was to identify, develop and eventually implement novel approaches to the use of natural history. Education development efforts were partitioned across thematic subgroups so that 2-3 theme facilitators guided the analyses and discussion of a larger number of participants for each educational topic. The collective expertise of the AIM-UP! participants integrates across disciplines (e.g., phylogenetic analysis and theory; phylogeography, behavior, morphological evolution, arctic and tropical biology, and statistics), allowing for the development of diverse,

exciting, and conceptually broad curricula aimed at increasing the use of museum collections in undergraduate education. Sub-group facilitators oversaw the preparation of teaching modules or manuscripts associated with their thematic focus. The following modules were initiated or developed as part of the AIM-UP network (see <http://aimup.unm.edu/for-educators/index.html> for specific details on course level and sub-discipline):

Educational Modules

- Animal Responses to Climate Change
- Coal Balls
- GIS and Bats
- Hemoglobin Function and Variation in Wild Populations
- How to Read a Scientific Paper
- Introduction to Arctos
- Introduction to the Trilobites: Macroevolution Virtual Lab
- Island Biogeography
- Ornithological Geographic Variation
- Phylogenetics Activities and Project
- Plant Range and Distribution in Alaska
- Specialized Plant Pollination Systems
- Stomatal Density and Climate Change
- The Relationship between Geographic Barriers and Divergence
- The Rock Pocket Mouse, Adaptation by Natural Selection
- Using Natural History Collections and Art to Communicate about Climate Change

The RCN-UBE program is focused on community building. Modules were developed throughout the six years of the grant and were strongly informed by the Annual Meeting discussion, Regional Thematic Meeting working groups, and development opportunities related to professional meeting attendance and presentations. The nature of the RCN-UBE structure and goals would not fund specific module development. A pervasive theme across all meeting evaluations and the *Program Evaluation* was a frustration with the lack of resources to develop modules. In addition, few science or biology educators were involved in AIM-UP!

When participants were asked their level of involvement with each module, self-reporting on the *Program Evaluation* indicated 12 of the 16 modules were developed by one or two participants. The modules that are on the website were the result of individual efforts to push modules to completion. On one open question a participant noted, "I don't think people realize how much work creating the modules requires." When participants were asked, "What were our biggest challenges?" 12 of the 28 respondents noted the task of bringing modules to completion, citing lack of time, loss of momentum after annual meetings, and completion issues.

One overriding issue for the modules was the lack of a unified or validated assessment. In all cases, modules were implemented in at least one course (Hemoglobin Function and Variation in Wild Populations has now been implemented in an introductory core course at University of New Mexico) and several users noted they were involved in module assessment (see *Program Evaluation* Question 7). A notable number of individual assessments were conducted for modules implemented in the classroom. While assessments were conducted, it is not clear how assessments informed the modules and learning outcomes were not directly assessed. The assessments would benefit from the oversight of a science education professional to assure the proper questions are addressed, the results are accurately interpreted, and results are used in a formative way to improve modules.

Module development was a big challenge for the AIM-UP! community. Through the hard work and diligent effort of the AIM-UP! participants, 16 modules are currently available and can be implemented in the classroom. This is a tremendous resource and an excellent outcome for the AIM-UP! RCN-UBE. Moving forward, these modules can serve as the foundation for a targeted module development and dissemination. AIM-UP! has initiated this effort by applying to facilitate multiple workshops at the National Academies/HHMI Summer Institute on Quantitative Biology. This summer workshop, titled "*Lowering the Activation Energy - Quantitative Biology Summer Institute 2016*" is being hosted by QUBES, BioQUEST, and the Science Case Network, in Raleigh, NC. This opportunity has been funded in part by the BCoN and will facilitate module assessment, modification, implementation and dissemination. The summer workshop will further enhance current efforts to create a Faculty Mentoring Network through QUBES. AIM-UP! has also partnered with the iDigBio E&O Working Group, WeDigBio, Esri, ESA, and KURATOR on a funded proposal to iDigBio for a 2017 workshop based on AIM-UP! module development and dissemination, titled "Building and Disseminating Resources for Collections-Based Undergraduate Education." AIM-UP! will be continuing forward with optimizing, developing and disseminating modules and has effectively identified a "next step" in continuing module development.

Educational Videos

Educational videos were initiated in year three of the grant and completed by ScienceLive (<http://www.science-live.org>). A set of videos was developed as a medium to introduce the educational value of collections and these were targeted for instructors. The second set was developed to be engagement exercises that could be used in a classroom to introduce a potential educational module.

Videos - Educational value of collections

Faculty Perspectives: The Value of Collections in the Classroom

Introduction to AIM-UP! Advancing Integration of Museums into Undergraduate Programs

Students Perspectives: Collections as an Untapped Teaching Tool

Videos - Student Engagement

Meet a Curator: Dr. Rick Williams

Student Perspectives: Learning Behind the Scenes

Aquatic Invasive Plants: Following the Data (<https://vimeo.com/156926248>)

The videos were well received by the community. These are relatively new additions to the AIM-UP! educational portfolio. On the *Program Evaluation*, participants were asked "If you used one or more of the videos, please describe how you incorporated them into your course." Almost half of the respondents (6 of 13) indicated that the videos had been or would be used in in course work. Two respondents noted they would use them in the future and three noted how they would be valuable in advocating for collections. These videos are relatively new and provide an additional support tool for undergraduate educators and museum professional to teach about and advocate for collections and collection science.

Seminar Course:

An annual web-cast seminar series was held annually at UNM on the use of archives in contemporary research (UNM, UC Berkeley, Harvard, University of Alaska Fairbanks and in one year, Occidental College). At the beginning of each seminar an overview of *Vision and Change* was presented to set the stage for how educators are attempting to change undergraduate course delivery. The course syllabi for each year are available on the AIM-UP website. As a course requirement in all of these seminars, students proposed and began to build educational modules that were based on museum collections. Several (13) of these were further refined to the point of inclusion on the website. Topics for the seminars are listed below:

Year I: Integrative Inventories

Year II: Co-Evolution: Art + Biology in the Museum

Year III: Evolutionary Dynamics of Genomes

Year IV: Biotic Response to Climate Change

Year V: Human Dimensions of Natural History

This was an impressive effort among several universities. The use of the seminar courses to teach about collection science and engage students in module development and implementation was a smart use of resources and a great way to engage early professionals in collection science. Standard UNM student evaluations were conducted on the majority of these seminars. The format of the evaluations is not conducive to inclusion in this evaluation.

Workshops, Symposia, Webinars, Presentations and Publications

Starting early on in the development of AIM-UP!, a concerted effort was made to present posters and talks at meetings relevant to the overarching AIM-UP! mission. The efforts to disseminate information about the network and resultant products included posters and talks at national and international conferences, workshops and symposia related to using natural history collections in undergraduate education, a national webinar presentation, and several publications. For complete citations (<http://aimup.unm.edu/about/presentations-publications.html>).

Workshops Conducted by AIM-UP!

- American Indian Society for Engineering and Science (AISES) National Conference, Anchorage, 2012
- Life Discovery – Doing Science Education Conference, San Jose, CA, 2014
- National Academies/HHMI Summer Institute on Quantitative Biology (presented by QUBES, BioQUEST and the Science Case Network), Raleigh, NC, 2016 (*In preparation*)

Symposia Conducted by AIM-UP!

- Association of Science-Technology Centers (National), Albuquerque, 2013
- American Society of Mammalogists, Oklahoma City, OK, 2014

Webinars

- Small Collections Network Webinar, internet, 2014

Presentations at National and International Meetings

- NSF-URM Principle Investigators Workshop, Arlington, VA. 2011
- Society for the Preservation of Natural History Collections, San Francisco, 2011
- CollectionsWeb Meeting, Radford, VA, 2011
- American Society of Mammalogists, Portland, OR 2011
- Evolution, Norman, OK 2011
- Evolution Society, Ottawa, 2012
- American Society of Mammalogists, Philadelphia, 2013
- CollectionsWeb Meeting, Washington, D.C., 2013
- Curso de Biodiversidad, Ecología y Conservación de Los Roedores Neotropicales, Arequipa, Peru, 2013
- iDigBio E&O Workshop, Gainesville, FL, 2014
- Small Collections Network Meeting, Mt. Pleasant, MI, 2014
- Collections for the 21st Century Symposium, Gainesville, FL, 2014
- Society for the Preservation of Natural History Collections, Cardiff, Wales, 2014
- Botanical Society of America Annual Meeting, Boise, ID, 2014
- Northwest Biology Instructor' Organization, Bellevue, WA, 2014

- Society of Vertebrate Paleontology Meetings, Berlin, Germany 2014
- International Society for Biological and Environmental Repositories 2015 Annual Meeting, Phoenix, AZ, 2015
- Society for the Preservation of Natural History Collections, Gainesville, FL, 2015
- Evolution, Guarujá, Brazil, 2015
- Undergraduate Biology Education Research - Gordon Conference, Lewiston, ME, 2015
- AIBS Council Meeting, Washington DC. 2015
- RCN-UBE Summit, Washington DC. 2016
- Annual Ecological Society of America Conference, Fort Lauderdale, FL (Invited abstract; accepted for 2016)
- Society for the Preservation of Natural History Collections, Berlin, Germany (abstract submitted for 2016)
- Botany, Savannah, GA (abstract submitted for 2016)

Publications

- Lacey, E. A., T. T. Hammond, A. Mast, R. P. Guralnick, A. Monfils, J. McCormack, L. Ellwood, P. Soltis, D. Soltis, K. Bell, S. M. Ickert-Bond, S. V. Edwards, and J. A. Cook. *In Review*. Climate Change, Collections and the Classroom: Using Big Data to Tackle Big Problems. *International Journal of Science Education*
- Monfils, A.K., K.E. Powers, C.J. Marshall, C.T. Martine, J.F. Smith and L. Alan Prather. 2016. Natural History Collections: Teaching about Biodiversity across Time, Space, and Digital Platforms. *Southeastern Naturalist* (In Press). Powers, K.E., L.A. Prather, J.A. Cook, J. Woolley, H.I. Bart, Jr., A.K. Monfils, and P. Sierwald. 2014. Revolutionizing the use of natural history collections in education. *The Science Education Review* 13 (2): 24–33.
- Cook, J.A., E. A. Lacey, S. M. Ickert-Bond, E. P. Hoberg, K. E. Galbreath, K. C. Bell, S. E. Greiman, B. S. McLean, S. V. Edwards. 2016. From Museum Cases to the Classroom: Emerging Opportunities for Specimen-Based Education, Pp in Pavlinov, I., ed. "Aspects of Biodiversity" Volume 54 of the Archives of Zoological Museum of Moscow State University. In press.
- Cook, J.A., S. V. Edwards, E. Lacey, R. P. Guralnick, P. S. Soltis, D. E. Soltis, C. Welch, K. C. Bell, K. E. Galbreath, C. Himes, J. M. Allen, T. A. Heath, A. C. Carnaval, K. L. Cooper, M. Liu, J. Hanken, and S. Ickert-Bond. 2014. Natural History Collections as Emerging Resources for Innovative Education. *BioScience* 64:725-734.
- Ho, S-H. and J. A. Cook. 2013. Co-Evolving Pedagogies. *ARID: A Journal of Desert Art, Design and Ecology*. Vol. 2 published online
- Dunnum, J. L., and J. A. Cook. 2012. Gerrit Smith Miller: His influence on the enduring legacy of natural history collections. *Mammalia*, 76:365-373.

Proposals including AIM-UP!

- RCN-UBE: 3dNaturalists bioblitzes, citizen science, and undergraduate learning. Division of Biological Infrastructure - Human Resources (NSF). 2016. G. Bowser (Colorado State University; CSU), D.W. Husic (Moravian College), A.K. Monfils (Central Michigan University), J.C. Moore (CSU), and T. M. Mourad (Ecological Society of America). *Recommended for funding*.
- Workshop: 3dNaturalists: Using citizen science, bioblitzes and the National Park Service Centennial to promote undergraduate learning in biology. Division of Biological Infrastructure - Human Resources (NSF). 2016. G. Bowser (Colorado State University (CSU), Uwe Hilgert (University of Arizona), A.K. Monfils (Central Michigan University), D.W. Husic (Moravian College), J.C. Moore (CSU). *Funded*.
- (as Broader Impact) CSBR: Natural History: Upgrade and transfer of the Museum of Southwestern Biology's Division of Genomic Resources frozen tissue collection to nitrogen vapor storage. (NSF1561342) 5/1/16-4/30/2019 Funded. Cook (UNM PI)
- (as Broader Impact) NSF-1311076 DISSERTATION RESEARCH: Elucidating Evolutionary Histories of Multiple Chipmunk Parasites Using Next Generation Sequencing (Cook/ Bell; 7/1/13-7/1/15)

Outreach was a real strength of AIM-UP! The project was very deliberate in disseminating information in a range of available venues from discipline specific national meetings (e.g., Botany, Vertebrate Paleontology, Mammalogy) to national and international meetings that bridged disciplines (e.g., SPNHC, Evolution, Gordon Conference). In the Final Assessment Survey, 21% of the respondents (12/56) noted they had officially represent AIM-UP! at conferences, workshops or meetings. The RCN-UBE made efforts to sponsor presentations for participants in the network from a diversity of educational institutions (e.g., community college, primarily undergraduate institutions, comprehensive and RI universities), this facilitated dissemination to a broad audience and supported efforts of educators by sponsoring their participation in national meetings. Efforts were made to present in educational forums (e.g. Northwest Biology Instructor' Organization, Life Discovery – Doing Science Education Conference, Gordon Conference on Undergraduate Biology Education, QUBES) and to a diverse audience (e.g. AISES National Conference, NSF-URM Summit). The publication history of the RCN-UBE is impressive. In the Final Assessment Survey 46% (26/56) authored or anticipate being an author on a manuscript promoting the use of natural history collections in undergraduate education. To date, seven publications, a broad and inclusive set of authors, and impactful manuscripts are a credit to the collaboration.

The workshop held at Association of Science-Technology Centers workshop in 2013, was assessed as a whole and a report was submitted back to participants. The majority of respondents to all questions agreed that the workshop was relevant, useful and effective. Kayce Bell a graduate student in the Cook Lab at University New Mexico made the presentation. It is notable that she was ranked highest among the speakers for being

knowledgeable and engaging. A workshop conducted at the 2014 American Society of Mammalogists Annual Meeting had 51 respondents, the majority of whom were educators, who had worked in natural history collections and used specimens in the classroom. The majority did not use on-line databases in intro or advanced undergraduate courses. In responses, 50/51 respondents saw the benefit of using specimens or databases in the classroom and over 45 of the 51 respondents intended to use on-line databases in future courses. Overall participation and responses from both assessed workshops, show an interest from the community for the development of natural history collection based materials for integration into the undergraduate curriculum. Attendance at both these workshops was high and a good indication of an ongoing commitment on using specimens and databases in the classroom.

The RCN-UBE did extensive outreach to inform about the value of natural history collections in undergraduate education. As the materials and modules develop, continued dissemination will be imperative. This includes reaching out to the science education community and the venues in which they participate. Efforts were made to arrange a symposium at SACNAS (2013) and present at the National Association for Biology Teachers (2014) but those efforts were declined by the organizing committees. Perhaps as modules develop further, the next step would be to provide symposia and workshops at national meetings of educators (i.e. SABER). The presentation of AIM-UP! at the upcoming BIOQuest Summer Workshops and participation in a Faculty Mentoring Network through QUBES, are good first steps in reaching the broader community. Upcoming initiatives in conjunction with the iDigBio E&O working group, KURATOR, Esri and ESA will also assist with broader dissemination. This will benefit the community in increasing the likelihood of implementation and also recruitment of biology educators into the continued effort.

Outreach to other networks and groups

When submitting the initial proposal, Aim-UP! had one PI (Cook) who was on the Steering Committee of the CollectionsWeb RCN and another who participated in a meeting of the CollectionsWeb RCN. They had been invited to participate in the Annual CollectionsWeb RCN meetings at Radford and Washington DC on undergraduate student participation in collections-based research. Throughout the grant, AIM-UP! continually reached out to other existing programs, networks, and groups. This included sending Representatives from AIM-UP! to participate in other groups and emerging initiatives as well as inviting members of existing groups to AIM-UP! meetings.

Representative participation with networks and groups:

- Animal Diversity Web
- ARCTOS
- Biodiversity Collections Network (BCoN)
- BioQuest
- CollectionsWeb
- Encyclopedia of Life, KURATOR

- Esri
- Integrated Digitized Biocollections (iDigBio)
- InvertNet
- Natural Science Collections Alliance (NSCA)
- Open Science Network in Ethnobiology
- Quantitative Undergraduate Biology Education Synthesis (QUBES)
- Small Collections Network (SCNet)
- Society for the Preservation of Natural History Collections (SPNHC)
- VertNet

Again, AIM-UP! did an impressive job of reaching out to the community and allying efforts with existing and emerging programs. Continuing participation of participants in other growing efforts and new RCN UBEs (https://qubeshub.org/groups/rcn_ube2016/collections/rcn-ubes) would help maintain the legacy of the AIM-UP! program.

Integration across disciplines

The PIs of AIM-UP! acknowledged the importance of working across sub-disciplines. Traditionally collections professionals work exclusively within their taxonomic field of expertise and attend discipline specific professional conferences. In effect these professionals can become silos of expertise. The down stream affect is redundant research and students who do not see the connections across disciplines and perpetuate the isolation. The participants in AIM-UP! includes collection professionals from a broad diversity of institutions that support physically, ecologically, and culturally distinct collections. Participants have expertise on a wide variety of organisms. Participants included individuals with traditional roles at university museums, and in academia, and professionals from federal agencies.

The first year of AIM-UP! was focused on Integrative Inventories and bringing together experts from a variety of disciplines. The annual theme and seminar united scientists and students with a diverse set of taxonomic expertise to explore the potential of combining biodiversity data across taxonomic and disciplinary boundaries.

In the second year the seminar series and annual meeting were centered around the interface between Art and Museums and co-led by Cook and an Art Professor from UNM (Szu Han Ho). The semester long course drew students from Art, Biology and the Honor's College. In addition to weekly seminars, 3 two-day workshops (including one public lecture) were held that were led by artist who explore biology in the work ([Cataloguing Wonder: Brandon Ballengée](#), [Fluid Taxonomy: Suzanne Anker](#), and [Morphology and Evolution: Brian Conley](#)). Four educational modules based on collections (called dispersion modules by the artists) were developed and are posted on the website.

This network drew from a broad array of biologists. Reaching out to artists brought a

new dimension to the RCN-UBE. Future efforts would benefit from reaching out to paleontologist, anthropologists, and science educators (something noted on some post-meeting surveys and the *Program Evaluation Survey*). Continued inclusion of geographers, data scientists and quantitative biologists will be vital as more and more data resources become available.

Broadening Participation in the Network

The PIs made a conscious effort to include individuals with varied backgrounds and divergent perspectives including diverse collaborators (including minority and female scientists), federal agency biologists, academics, international participants, and museums with large public audiences. Of the 115 recorded participants in AIM-UP!, 38% (44) presented as female and 20% (23) were from underrepresented populations. Given the diverse pool of students at each participating institution that are interested in biology, the seminars were a good first step to identify, recruit and train undergraduates into museum-based biology. Nine of the 30 students who participated in the AIM-UP! seminars (30%) were from underrepresented populations.

A particularly successful outreach project from AIM-UP! was based in Alaska and led by Steffi Ickert-Bond and co-presenters K. Winker and A. López. They proposed, had accepted and organized two mini-workshops for the 2012 AISES National Conference, in Anchorage, Alaska: A) Using natural history collections in biodiversity research and education at a University museum. B) Improving STEM teaching through integrating and building natural history collections: Applications for understanding climate change, sustainability, and adaptation.

The Flagstaff Regional Thematic Meeting was focused on incorporating natural history collections into indigenous education. Reviewing comments made on pre- and post-meeting questionnaires highlights the importance of addressing and understanding the challenges of Native students. Pre-meeting, participants noted the challenges of information technology on Native lands, integrating cultural values and culturally relevant modules, incorporating indigenous knowledge, and acknowledging the history of abuses by museums to native populations. Post-meeting feedback indicates 100% of participants felt the meeting met expectations (including 4 Native American educators from 4 institutions), had valuable presentations and helped them to clarify how museum collections might be used in undergraduate education, especially with Native students. Comments and suggestions for future work focused on the need for more meetings and development incorporating challenges (and solutions) for Native students, including representatives from tribal colleges, and development of culturally inclusive modules.

This network was diverse and inclusive. In the *Program Evaluation Survey*, participants were asked to evaluate how important they thought broadening participation among underrepresented groups was as a next step for AIM-UP! In response, 86% of the respondents thought this was important or very important and many follow up

comments reiterated a need to emphasize this in future endeavors. Continued efforts to broaden participation will strengthen the community and are consistent with the emphasis already initiated by the RCN-UBE.

Summary:

The AIM-UP! RCN -UBE has been successful at reaching the primary program objectives. Aim-UP! is broadly-based and diverse network of undergraduate educators, curators, collection managers, database managers, scientists, and others (artists, federal resource managers). This community of scientists and practitioners have come together and started a national discussion about emerging possibilities in specimen-based education. Module prototypes and educational videos have been developed that can be used in the undergraduate classroom to engage students in collection science. Next steps are in place to sustain the network and further develop the modules, assess student outcomes, disseminate materials and embed specimen based science in the undergraduate curriculum.

The yearly "all-hands" meetings were a key factor in establishing and growing the network. The yearly meetings were influential in creating a sense of community and participants became vested in seeing the network grow and be productive. The open discussion, presentations, and working groups brought together a diverse group of educators, collection and database managers, and scientists. The inclusion of representatives from different disciplines, research strengths, and institution types resulted in a broadly based and diverse network. Regional and thematic meetings were important when maintaining momentum between annual meetings. These smaller meetings facilitated more intensive development of module prototypes, submission of manuscripts, and visioning the next steps for promoting greater inclusion of collections and collections data in the undergraduate classroom.

Outreach to the collections community and other networks and groups, was truly impressive. Over the six year course of the grant AIM-UP! produced seven manuscripts (6 in press or published, and one in review), presented over 25 talks or posters at national and international meetings, and ran 5 national symposia and workshops. In addition, AIM-UP! has been included as a key component of several funded and pending national grants.

The AIM-UP! community has built a good momentum and is well situated to build on products from the RCN-UBE. Sustaining the momentum will be the next challenge. Efforts to align goals with the iDigBio E&O Working Group, create a QUBES Faculty Mentoring Network, and participate in the National Academies/HHMI Summer Institute on Quantitative Biology are all promising steps. These efforts can serve as a springboard for module development and implementation. The challenge will be sustaining the efforts in the absence of grant funding.

As the AIM-UP! network continues to evolve, it is important to continue to diversify participation across disciplines. An emphasis on broadening participation needs to be sustained and more small collections, and educators from primarily undergraduate institutions, need to be brought into the network. It is imperative for the group to incorporate science educators as key collaborators early in the process of module modification. Communication will be a challenge but it is important to retain the cohesive yet growing network. With the newly evolving opportunities, it is vital to reach out to the participants, inform them of emerging opportunities, and aggressively encourage participation and inclusion. Webinars, a continued web presence (e.g. blog, listserv, twitter account), and newsletters are all virtual ways to remain connected. An open call for participation in the QUBES FMN and a revamped website are two possible ways to engage participants, sustain energy, and encourage network participation. There is a lot of positive energy in the group, the AIM-UP! network is well situated to continue building the network and developing resources and opportunities related to collections in education.