# Digitized Biodiversity Collections – Engaging K-12 Audiences

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**Preface**

Natural History collections in the United States are currently undergoing a transformation, one that will ultimately result in millions of specimens in research collections being digitized and aggregated on-line in the Cloud. Taken together, these specimens are the single largest repository for documenting the biodiversity on earth today as well as life that existed in the past.

The process of producing digitized collections, i.e., digitization, can mean many things to different people. In the context here, natural history museum collections are digitized when the specimen catalog data and associated metadata are captured in an electronic format, such as on a database. Ultimately in the best case scenario, these data are then aggregated and made available on line. A more recent development has occurred in which media, most notably images, are attached to specimen data records. The iDigBio portal (https://www.idigbio.org/portal) is an example in which as of the middle of 2017, more than 100 million vouchered specimen records and 20 million associated media records are aggregated on line. These will ultimately be accessible to a potentially broad spectrum of "down-stream users," or potential audiences other than researchers who might access these data and resources.

One such broader impact audience is represented in K-12 education, including more than 50 million students and more than 3 million teachers in the U.S. today. Despite this large potential target audience for Broader Impact outreach activities related to digitized natural history museum specimens, many natural history museum professionals are generally unfamiliar with how to reach out to, an understand the needs of, this audience. This workshop therefore provided an opportunity for experts in both collections and education to interact, share knowledge, discuss challenges and issues, and ultimately collaborate on this best practices document that can be shared with the greater collections community.

This "white paper" was generated during a workshop sponsored by iDigBio (https://www.idigbio.org; Page et al. 2015) entitled "Incorporating K-12 Outreach into Digitized Biodiversity Collections Programs." This workshop was held on 5-6 December 2016 at the Q?rius Center at the National Museum of Natural History, Smithsonian Institution, Washington DC. The purpose of this workshop was to develop this document for its intended audience, i.e., members of the natural history digital collections community seeking to improve and integrate STEM education and teacher professional development within K-12. It is our belief, which also has been noted by NSF program officers, that research scientists and collections professionals may not have the expertise and understanding who to effectively propose and implement K-12 education and outreach, and hence both this workshop and document were envisioned.

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**Acknowledgments**
This workshop was funded by NSF 1547229 (iDigBio, Phase II). We thank Amy Bolton and her colleagues at Q?rius, The Coralyn W. Whitney Science Education Center, for providing this stimulating venue for this workshop. Thank you to Laura Speer and Liani Yirka for feedback on earlier versions of chapter 5.

**A dozen** Recommendations for digital collections for K-12

1. **Establish clear and realistic goals** - start small and build up.
2. **Identify and learn about your audience –** find someone who is in K-12 education, survey teachers, find related curriculum standards,, meet with community leaders, build on relationships, find out what is realistic with technology in schools.
3. **Build relationships –** establish a mutualistic relationship. Engage your community and find out what their needs are.
4. **Don't reinvent the wheel -** leveraging existing products, especially technology, for use in your projects before you develop your own. Consider collaborating with other experts.
5. **Know your power structure-** Find support from higher level administrators/principals, learn about the demographic of the school, community leaders
6. **Be intentional about inclusion and accessibility –** audio/transcription, use of 3-D printed replicas, translations into multiple languages, subtitles, differentiation possibilities
7. **Build in local context (when possible)** Provide local /outdoor resources to give meaning **–** where is it from, can students go see something similar,
8. **Consider real world relevancy –** health, economics, environments
9. **Plan for evaluation from the beginning** - Meet with your evaluator at the very beginning
10. **Sustainability** (consider the realistic lifespan of your projects and products, especially technology, when proposing education solutions to partner communities.)
11. **Be flexible -** Be prepared to receive feedback from educators and learners and modify your content accordingly.

**Leverage existing and emerging outlets for communication** - Plan on how you disseminate and promote your resources (Swag! Advertising, social media) and find early adopters.

**Chapter 1**
# Integrating digitized biodiversity collections into learning settings in school and out: Benefits, needs, and challenges

## Introduction

K-12 educators and learners are a large and appropriate audience for outreach activities associated with scientific projects, and are often the target audience for activities incorporated into the statement of Broader Impacts for NSF proposals. Science is increasingly emphasized in K-12 classrooms and informal settings, and is a critical component of current STEM (Science, Technology, Engineering and Math) and STEAM (STEM + Art) educational initiatives. A critical step in working with this audience--or any audience for that matter--is to see the project from their perspective and to include them as co-creators.

Understanding how your project benefits your audience, taking into consideration what they need and being aware of their particular challenges greatly increases the success of your project while building a relationship with your end user. The old model of 'build it and they will come' is no longer valid in a crowded digital education landscape that increasingly demands demonstrated success.

## Communicating the Benefits of Engaging K-12 Audiences with Digitized Biodiversity Collections

Biological specimens provide a tangible record of life on earth. Housed in natural history collections, they range from fungi to fish and birds to butterflies. With technology innovation, museums have the opportunity to make these collections available beyond the physical confines of the institution and foster awareness and understanding of their value to society. Digitized collections are critical sources of evidence to address questions of local, national or international importance about biodiversity and the evolution of life, as well as questions related to the environment, agriculture, and public health. For example, they can help us understand climate change, the spread of diseases, and the impacts of draining a wetland. Developing an appreciation for collections as a vital resource for understanding today's world and their potential for making connections between the past, present, and future, can build support for the long-term conservation and preservation of collections.

As primary sources, digitized biodiversity collections are used in science research. They also can:

- Engage K-12 aged audiences in real-world science investigations to develop understanding of science practices, core ideas, and crosscutting concepts;
- Provide broad accessibility to audiences in rural, suburban, and urban environments;
- Meet national and state education standards and/or organization goals;
- Foster science awareness, interest, and engagement;
- Promote 21st century learning skills;
- Broaden student perspectives on what science encompasses and develops awareness of career options in natural history related fields;
- Provide connections among formal, informal, home, and other settings; and
- Be responsive to learner interests, experiences, capabilities, and cultural practices.

For researchers seeking funding, engaging K-12 audiences can fulfill certain aspects of broader impact requirements. In addition, researchers can expand their research team by engaging K-12 learners in their work. Studies have also shown that in return, scientists also derive benefit from working with teachers (Tanner 2000).

**Why Audience Engagement is Essential**

A savvy potential user of your product or activity will ask the question, “How do I know this will work?” and “Why should I use this in my classroom?” Your audience and stakeholders are the experts on what they need and what challenges they have that they would like to overcome. It is easy to make assumptions about the audience, many of which could be wrong, and fall into the trap of over generalizing what can be a complex learning experience. Having an understanding of your audience before your project is developed saves you time and helps you avoid making crucial mistakes that undermine your project’s success.

Engaging your audience from the beginning also gets you buy-in from your stakeholders--an important element to seeing your project widely adopted and ensuring a broader impact. When the audience is involved from the beginning, you will benefit from their motivation and they will benefit from a product that they recognize as useful. Co-creating your project with the audience will ensure both parties will get what they need from the project.

The best way to understand your audience is to talk to them: ask them questions and share your ideas while listening to their feedback. We offer an overview of important audience needs, benefits and challenges derived from a national survey that can begin a conversation about how to engage your audience. The evaluation section of this document will offer more details on how structure getting audience input and using that input in your process.

**Build Programs with Your Users in Mind from the Start**

Success in developing and implementing programs, classroom lessons, and other learning resources based on digitized biological collections depends heavily on getting to know your audience. It is essential that you consider the needs, challenges, and benefits of working with your intended audience early in the design stage. This section will highlight some important factors to keep in mind as you create lessons for K-12 audiences.

*Define Your Audience and Identify its Needs*

First and foremost, it is essential to define your audience. Everything that you create as you develop your program will depend on who you envision using the final product, so choose your audience as early as possible, and learn as much about them as possible. Think about whether you would prefer for your content to be delivered through a formal (traditional K-12 school setting, whether public, private, or homeschool) or an informal setting (4-H programs, Boys and Girls Club, afterschool programs, science clubs, etc). There are pros and cons of each. We often think of formal education as we develop our programs as this is often a more familiar approach to start with, but there also challenges with working with this audience. Formal educators are tied very heavily to their curricula and are often constrained in the things they can bring into their classrooms or the sorts of field trips they can do. Informal education settings can be more flexible in what they offer, but they sometimes have specific organizational goals or policies that you will need to be aware of and incorporate as you develop your program components.

Once you have chosen an educational format, it is helpful to consider what the students you wish to reach are learning in school so that you can narrow your focus to age groups who might find your lesson useful and interesting. Formal educators are often required to choose experiences for their students based on curriculum requirements and informal educators can be constrained by the mission of their organization. If your content or chosen age group does not fit these requirements, you are unlikely to reach the audiences you seek. Remember: you do not need to reach every possible group with your program! If something you develop is strongly suited to a particular age group or grade, there is no reason not to focus on those groups rather than trying to force a fit with others.

*Appealing to Students, Educators and Administrators: Overcoming Challenges and Meeting Needs*

As mentioned above, every project needs to have a clearly defined audience. The audience, however is also supported by other stakeholders who have important influence over the success of your project. As you develop your programs, remember there are three levels of people you need to appeal to: the students, their teachers/educators, and the administration of the school or organization. We consider each of these groups separately.

<u>Students</u>

The students are ultimately the audience of your program. The way K-12 students learn science has changed significantly in the past few decades and has shifted from a top-down knowledge delivery system to a more student-driven, inquiry-based approach. Successful programs generally include some or all the following:

- Hands-on activities
- Opportunities for self-directed learning
- Access to mobile or other technology
- A clear understanding of why they should care
- Relevance to their own lives and/or skills and information that will be useful in the future

Technology, particularly mobile technology, plays a huge role in the everyday lives of many students. However, it is also important to keep in mind that not all schools/organizations, and certainly not all students, have access to technology. You may inadvertently preclude participation in your program if it requires access to a particular technology students do not have access to that you do not provide yourself.

<u>Educators</u>

In most cases, it is the educator who decides which specific lessons, programs, or field trips are incorporated into the classroom/center educational plan for the year. They have limited time and resources, so they often look for specific things as they plan their curriculum. These include:

- Correlations to standards and curriculum or organizational mission correlation;
- Learning curve for implementing new technology, content or teaching methods;
- Potential for improved student comprehension and increased science skills;
- Sufficient background information and/or professional develop/training that helps overcome any perceived discomfort with the content;

- Affordable (free is ideal!) and uses accessible resources/technology; and
- Ability to adapt the lessons to their specific needs/classroom.

Administrators

All this said, administrators also play a role in deciding which experiences students have, especially when choosing field trips. Principals and other administrators often consider the following:

- The lesson meets curriculum correlations or an organizational mission;
- Educator support (professional development, resources, stipends, etc) is offered, especially experiences that lead to improved teacher effectiveness;
- Evidence of the potential for improved student achievement;
- Teacher motivation, including the motivation to incorporate emerging technologies more effectively;
- Equity across classrooms;
- Getting buy-in from parents; and
- Sustainability.

When all is said and done, what superintendents want to know, and need to be able to communicate to their board members and parents, is that the program or intervention resulted in improved student achievement. Without an understanding of this, programs lack accountability and justification for return on investment, whether it be time, funding, or other resources (e.g., space).

Finally, overarching considerations for every project include the technology infrastructure needed to implement your project as well as the funding required not only for your project to be developed but for its implementation in the learning setting.  Include in your discussions with stakeholders a conversation about the hardware, software, security and bandwidth needed to ensure your project is seamlessly integrated into the learning setting.  Understand that bringing a new product into the classroom may have costs you may not envision and consider them in the development of your product.

Whatever you want to do and which audience you wish to reach, it is always worthwhile to develop your program with educator collaboration.  Teachers and administrators have extensive knowledge of their needs and constraints and you will need to work within these if you want to reach their students.  We encourage you to talk to educators, whether those in your museum or teachers in your local community, and involve them in your program development from the start.  Consider also connecting with national, state, and local organizations such as the National Science Teacher Association to connect with educators.  Collaborating with educators early in the design process is often an efficient way to ensure that your program is appealing, useful, meets the needs of all parties, and successful.

## Chapter 2
## Using Objects and Collections Data in K-12: theory and practice

### Real and digital objects in a Natural History Collection

In the 21st century, every natural history collection professional is responsible for both real and digital objects and data. All natural history objects (NHOs) are composed of two linked parts – the specimen and the associated collecting data that marks where, when, and in what condition the specimen was encountered. For the purposes of this chapter, real objects are the original specimens and associated data that can be held in your hand. Digital objects may be a computerized record of the data (database entry), an image of the specimen, or even a scan of an original field notebook (.pdf file). Lastly, with new and emerging technologies, specimens may be represented as 3D renderings and viewed as WebGL or via Augmented and Virtual Reality platforms.

Research in natural history collections is extremely variable, ranging from fundamental inquiry-based research to management-oriented questions, to species identification. Each of these categories offers straightforward, concrete questions that students of all ages can relate to, if only by asking, "what is it?" Collections provide students an accessible "point of entry" that connects them with abstract scientific concepts while promoting critical thinking and scientific inquiry.

Collections professionals are comfortable using and caring for collections. However, learning to work within a K-12 educational framework poses a challenge for those who are unfamiliar with current concepts in educational theory and approaches in serving the learning needs of diverse audiences. Today's educators work under an increasingly demanding environment of expectations and constraints. In this chapter, we briefly identify and explain current concepts in educational theory that are important for collections-based educational activities, discuss the advantages of digital objects in formal and informal educational settings, and present and analyze a successful educational resource produced by the iDigPaleo TCN.

### Theory of Object-based Pedagogy

Object-based pedagogy, which is defined as object centered teaching and learning, can provide engaging experiences for students in making meaning about scientific concepts and phenomena. Providing opportunities for students to interact with physical or digital objects provides a concrete multisensory link with scientific concepts while promoting deeper engagement and motivated learning. Objects prompt dialogue, critical thinking, curiosity, and reflection, especially when it is not apparent what an object might be. In essence this is science in its most fundamental form. Whether real or digital, objects and their data can serve as an anchor in connecting shared and prior knowledge with new scientific concepts encouraging students to form new conclusions and promote transformative learning.

### Inquiry and Cognitive- based Learning

Inquiry is an instructional process for learning that involves observation and/or exploration of a phenomenon. Working directly with objects learners can be prompted with directed questions form a hypothesis based on prior knowledge, then conclude with a greater understanding of a scientific concept or phenomenon. The use of NHOs and their associated digital data can be an engaging way to foster the inquiry-process. The inquiry process can span a spectrum of interactions, from teacher-directed engagements to student-directed experiences. There are three goals of inquiry based activities: (1) to teach the process of doing science (e.g, observe, hypothesize, test; (2) to learn science-related skills (e.g., taking and recording measurements), and (3) to learn a scientific concept (e.g., variation). A good roadmap for understanding these activities can be found in the Science and Engineering Practices section of the Next Generation Science Standards (NGSS). NHOs can also promote cognitive-based learning skills as learners are encouraged to (1) compare and contrast (2) gain visual literacy skills via observation of spatial relationships, and (3) perform classification tasks by placing objects together based on their similarities and differences.

**Benefits of Digital Objects & Data**

In an ideal educational scenario, collections would be open for students to learn from objects in the same way that researchers do – by handling real objects. Students would make observations, formulate their own hypothesis, find specimens to test these hypotheses, collect data, and analyze that data to experience the methods of science and to learn a scientific concept.

Collections professionals, however, have an equally strong obligation to conserve and protect the collection for the long-term. Navigating this care/use balance is a daily concern and is an essential, although sometimes unpopular, barrier to collections use. From the educator's perspective, there are other student-centric barriers to access of museum collections and resources that need to be addressed, including the socioeconomic, geographic, language, cognitive, and physical limitations of the learning community.

Digital data provide a solution to these problems from both the curatorial and educational perspectives. While some of the sensory aspects of physical work on collections are lost, opportunities also arise to use rare, fragile, venomous, or endangered specimens that would be otherwise prohibited. Collections that are Darwin Core compliant, georeferenced, and connected to other similar collections open up new horizons for inquiry beyond what would be available using the real objects in a single institution. The process of digitization and georeferencing provides opportunities for students to learn new concepts and techniques in bioinformatics, geography and stratigraphy, and taxonomy and systematics. Finally, digital data can re-create a physical object by 3D printing or Augmented Reality, thus providing the benefits of real objects while protecting the collection and simultaneously engaging in cutting edge technology.

## New and Emerging Technologies

Digital datasets provide access to collections, but there is a sensory aspect that is lost when all activities are 2-Dimensional. Increasingly, 3-D technologies can be used to create specimen-based learning tools to fill this void. The two main avenues currently being explored by iDigBio TCN groups involve 3-D printing of collection objects, and the representation of specimens via the use of augmented reality technologies (Libraries-of-Life.org). Re-creating objects with 3-D printing can re-establish the tactile connection to a concrete object and all the benefits that interaction confers including enhancing spatial cognition as users manipulate and engage with otherwise untouchable objects. It remains to be seen how users value 2 and 3-D rendering relative to the "real" specimen.

Augmented reality (AR) provides an avenue for collections professionals and educators to create contextual-based learning in space and place by superimposing digital knowledge over the object. This promotes opportunities for deeper learning and places the object into a virtual contextual framework.

The advantages of new and emerging technologies like augmented reality seem clear, with preliminary research showing promising results in STEM education with potential benefits for English language learners (Solak et al., 2015). Research in this field will hopefully shed more light to its benefit and how might differences in learning outcomes be different with end-users after engaging with 3-D virtual vs real specimens. Immersive and computer vision technologies will redefine what we know about object-based pedagogy and are exciting new avenues for exploration and experimentation.

## The Practice of Using Digital Objects and data in K-12 education

Digitized objects have been used in many ways for both formal and informal educational environments as part of the ADBC/iDigBio Thematic Collections Networks. Each TCN has taken a different approach. Some examples include: (1) having students transcribe label data, (2) compare and contrast specimen traits using specimen images, (3) gathering new data by measuring digitized specimens, and (4) providing additional contextual data for the specimens that they are using (e.g., putting the collecting event into context).

The best projects result from meaningful collaborations with the end users. These generally encourage teachers to engage students in the scientific process by observing and exploring the digital objects and data, forming hypotheses that can be addressed by collecting data from the objects and datasets, and analyzing the data in a meaningful way. In addition to teaching science, these activities have the value added effect of enhancing student's mathematical and statistical skills along the way.

**Case Study using digital data: iDigPaleo (idigpaleo.org)**

iDigPaleo is an online portal which aggregates and serves collections data and images and provides learners the opportunity to use specimens and data in the same way that scientists do. iDigPaleo can be browsed by anyone with internet access, or users can create an account that unlocks access to additional functionality. These accounts provide opportunities for formal and informal educational environments and allow projects to be tailored to address state curriculum standards.

iDigPaleo has grown in scope from fossil insect specimens to include other paleontological projects (e.g., Cretaceous World TCN), leveraging existing infrastructure while increasing taxon diversity. Accessing information is intuitive and the data can be browsed by type of fossil, common name, age, or collection locality. Results can be filtered in a variety of ways, for example, to include only records with images and/or map data. Tools include zooming in or out, annotating points, boxes or polygons, measuring tools, and image manipulation. Digital objects can be grouped into subsets that can be tailored to curriculum standards, educational goals, a particular location, or a particular time period. Student accounts are linked to educators, who can share sets and view annotations and measurements.

One of the great strengths of iDigPaleo is that it can be used by the entire spectrum of educational levels. For example students could be asked to:

- **Grade K-5**: Create a gallery of fossil organisms and identify distinctive body parts (wings, suckers, modified appendages) from the collection. Analyze and interpret these features to predict what type of environment the insect inhabited (3-LS4-1 of NGSS).

- **Grade 6-8:** Compare modern insect species from Colorado and Wyoming to insect species found in the Eocene Green River Formation. What does this tell you about how climate has changed in the past 50 million years? (MS-ESS1-4 of NGSS) This example supports students in constructing a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.

- **Grade 9-12:** Measure the wingspan of odonates from the Carboniferous, Jurassic, and Recent. Extrapolate patterns in wingspan of Carboniferous and Jurassic odonates based on comparison with recent complete odonates. Use this data to form an argument of how insect body size is related to changes in oxygen levels over geologic history (HS-LS4-5 of NGSS). This example can support students in evaluating evidence in supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species).

**More Information**

- Next Generation Science Standards (NGSS): www.nextgenscience.org
- Common Core State Standards (CCSS): http://www.corestandards.org/
- 3-D Resources: www.shapeway.com
- 3-D model repository for 3-D printing or other platforms: www.Sketchfab.com
- Object-based Learning: http://www.ucl.ac.uk/museums/learning-resources/object-based-learning
- Augmented reality case study of a specimen-based learning tool: www.libraries-of-life.com
- Inquiry: https://www.exploratorium.edu/education/ifi/inquiry

## Chapter 3
## Online and Digital Resources: Design and Technology Considerations

To design effective K-12 outreach strategies and activities, members of the natural history digital collections community will benefit from a realistic understanding of the current K-12 digital learning landscape and an exploration of promising practices for the design and implementation of learning activities for digitized specimens.

The importance of improving access to digital resources to enhance student learning cannot be understated. The majority of K-12 teachers in the U.S. use digital media and technology in some aspect of their classroom instruction with most teachers reporting that they use the Internet for searching, finding, retrieving, and implementing digital media such as games, activities, lesson plans and simulations frequently or every day (Project Tomorrow, 2016a). *How*, rather than *if*, technology is used to access learning resources for teaching and learning is the differentiator.

### The K-12 Learning Environment

Relative to this white paper's discussion, three key aspects of the K-12 digital learning landscape are applicable: 1) students' access to and use of digital tools, content and resources for learning; 2) teachers' familiarity and valuation of digital content; and 3) the human and technological institutional structures that enable and constrain digital content usage within classrooms. Understanding these aspects can provide new opportunities for outreach within K-12 environments as well as identify potential challenges for those outreach efforts.

**Students' access to and use of digital tools, content, and resources for learning.** For today's students, the best learning is a 24/7 enterprise comprised of a seamless and customized set of engaging educational interactions with teachers, classmates, parents, and experts, some near and some far away. These interactions happen both in the traditional physical worlds of classrooms, libraries, community centers, and museums, as well as in the virtual spaces of social media, multiplayer online games, and online classrooms. From these interactions with digital content, tools, and resources for learning, students have created their own preferred vision for learning. The vision is predicated on students' experiential understanding of the potential power of collaborative learning; the immense capacity of new learning environments when they are un-tethered to traditional methodologies or resources; and the unparalleled relevancy of learning experiences that marry academic content with real world context (Lenhart, 2015; Project Tomorrow, 2016e).

Unfortunately, this vision is an inherently student-driven perspective that places a premium on self-directed, inquiry based learning and is often at odds with traditional school learning environments. While over three-quarters of high school students say they like learning, only four in ten say the skills or subjects they are learning in school will be helpful for their futures (Project Tomorrow, 2016e). In contrast, 79% of students say they regularly watch videos they find online to help self-remediate in an academic area or to learn about a future career; 55% use social media to learn about topics of academic interest and to follow experts in those fields (Project Tomorrow, 2016b). While access to technology has empowered students to pursue self-directed learning, the disconnect between students and school goes beyond a preference for digitally enhanced learning. Students want learning experiences that are highly personalized to their interests and technology provides an egalitarian way to do that easily and efficiently. Too often, traditional school environments, and even some out-of-school programs, still rely upon institutional structures (e.g., bell schedules, formalized curriculum, competency based upon standardized test achievements) that discount or devalue students' preferences for learning and even the use of digital tools, content and resources to support self-directed learning (Lenhart, 2015).

**Teachers' familiarity and valuation of digital content.** STEM teachers average about 10 hours of planning a week (Perrault, 2007a; Reid, 2014), and the majority of the time they spend online looking for curriculum materials occurs during the school day (Mardis, 2009). Teachers have said that they often do not have enough time to incorporate new digital resources into instruction because of the time it takes to locate and vet them and the hours it would take to define and engage in professional development to upgrade their skills to learn to use them fluently (Krajcik, et al, 2014; Perrault, 2007b). Teachers are unlikely to invest time in activities in which they do not feel confident (Recker, et al., 2007) and in which they do not see a benefit (Riel & Messing, 2011). Therefore, to change teachers' behavior in digital resource use and curriculum planning, resources must be easy to use and demonstrate immediate differences in student engagement (Maull, et al., 2010).

**Technological Institutional Structures that Shape the Learning Environment.** According to the latest results on the ongoing nationwide survey, school principals (94%) believed that the effective use of technology within instruction is important for student success. A majority of principals reported that they felt that integrated technology-mediated learning experiences increased student engagement (80%) and extended learning beyond the school day (69%). Principals see digital tools and collections as promising ways to provide learning personalization (60%) and increase the relevancy and quality of instructional materials (57%), (Project Tomorrow, 2016d), provided that their institution's facilities and practices enable digital resource use. Key affordances include:

***Open Educational Resources.*** Because the iDigBio natural history community's digitized specimens are freely available, they can be considered primary source open educational resources (OER). OER are free and openly licensed educational materials that can be used for teaching and learning. Just as with other digitized documents and artifacts, digitized biological specimens are primary sources, i.e., "the raw materials of history — original documents and objects which were created at the time under study." (Library of Congress, n.d.) These resources can be placed in a variety of contexts for many learning tasks. OER's educational potential centers on their ability to be integrated into a variety of tasks that can be tailored to each learners' needs and interests.

***Makerspaces.*** Makerspaces are a promising technology-mediated context for primary source OERs, like digitized natural history collections because they often have 3D printers, software, electronics, craft and hardware supplies and tools, and more. Secretary of Education King (2016) declared that innovation and making are cornerstones of an impactful K-12 experience. Imagine how the designs from the natural world could stimulate and expand the creativity of teens working with 3D printers or simple robotics. Makerspaces are especially well suited inquiry-based learning and allow students some autonomy to direct their learning.

***Internet Connectivity***. There are still schools that do not meet minimum bandwidth requirements, especially in rural areas and on Tribal lands (NTIA, 2017; Fox & Jones, 2016). Far less is known about children's out of school Internet access. Householders who lacked home Internet service but who had school-age children were less likely to report they did not need to than householders without school-age children (Horrigan 2015; NTIA, 2014). These gaps were seen most starkly in rural communities, where young learners have the least access to public libraries, museums, and other out-of-school learning venues.

**Promising Practices for Technology Usage in Educational Projects.**
PIs should always look toward existing projects and platforms for possibilities for partnership and leveraging before starting new technology development. Existing infrastructure (e.g., websites or apps) can be used as the foundation of educational outreach efforts to showcase specific content and research. What follows are some recommendations for using digital resources with K-12 students and educators:

1. **Establish your value proposition.** Do not underestimate the need to express the value proposition of using new technology with a group of students and educators. How does learning about this new technology address your learning goals? Technology in itself should not be used as a motivating factor to involve schools and other educational organizations in using digitized specimens.
2. **Lead with student voice and choice.** In their work with middle school students, Smithsonian staff consistently found that K-12 educators indicated that relevance to students' needs is a top priority (Smithsonian, n.d.). Research suggests that learning in formal and informal settings is most powerful when it is student led (Milligan, 2016; Smithsonian, n.d.).
3. **Match your approach to audience needs.** Contextualization is an important component of any program seeking to use technology. Digital resources could benefit from a primer or tutorial tailored to the audience you are targeting. Short videos and screencasts can capture just-in-time information for the successful use of digital resources. Be aware, users will bring their own expectations to offline and online digital resources based on popular online trends and platforms (e.g., Google, Amazon, Facebook).
4. **Co-design activities with educators.** Think about co-designing with educators and students in your project to authentically reflect the technology learning goals of your partners. Always adopt the mindset of continual improvement of your educational programs using technology. Consider iterative cycles of formative evaluation to dynamically customize a program for educators.
5. **Provide scaffolds and entry points.** Teachers and students are rarely certain where to begin with large digitized specimen collections. One helpful approach is to curate collections with themes or galleries connected to specific classroom activities. Another approach is to engage educators and learners through short videos and screencasts to guide users through collections.

6. **Use Universal Design to reach all users**. Don't assume available technology will specifically address the needs of people with disabilities. Does video need to be transcribed, can users with mobility impairments use the computer or other devices displaying content, or do alternatives to videos have to be provided to users with low vision? Review digital resources you plan to use with this lens.
7. **Choose source media in the public domain or with a Creative Commons license**. Rarely does media specifically address the target audience you are trying to reach, so consider the possibility of remixing and editing source material and its legal ramifications for reuse. Also, always consider the intellectual property restrictions of students sharing finished work adapted from the source media of digital resources.
8. **Leverage existing repositories and metadata standards.** Partner with established cataloging systems, biodiversity cataloging projects, and community websites to showcase your work for educators. When considering transcription projects or developing small digital collections as part of an educational project, review community metadata standards to make your data interoperable with existing biodiversity collections platforms. Don't try to start your own repository or website unless it is absolutely necessary. Sustainability is something niche cataloging projects are often unable to achieve.
9. **Link to existing networks and brands.** If you are using social networking platforms in your educational program try not to start your own brand unless absolutely necessary. Think about sustainability of your online presence and consider leveraging the subscribers/followers to popular institutions/groups. Popular institutions and groups you might be connected with have gone through various trials and errors to build up their brand and network. Don't be afraid to use them as your resource.
10. **Strategically use social media platforms.** Not all third party social networking platforms are created equal. For example, Pinterest is a popular source of ideas and sharing for K-12 classroom teachers and sharing. In designing and providing support to the educators, take into consideration existing communication channels that a commonly used by the teacher and/or student audiences you are trying to reach.
11. **Understand school technology infrastructure.** When developing a relationship with a school, be sure to ask what types of equipment and connectivity are in classrooms and ensure that your tools and resources are compatible. Educational technology includes a wide variety of tools and resources used to improve teaching, learning, and creative inquiry by students. Not all educational technology activities will work in all environments.
12. **Know the life-cycle costs of educational technology.** In educational experiences using technology you may have to consider maintenance, redevelopment, and third party subscription costs not included in initial development funding.

**Case Study: WeDigBio**

The Worldwide Engagement for Digitizing Biocollections (WeDigBio) Project is focused on engaging the public in creation of digital data about biodiversity research specimens. WeDigBio began as a collaboration among online transcription platforms to produce a four-day, annual WeDigBio Event and supporting technology and other resources. The WeDigBio Event engages participants at onsite transcription events held at museums, universities, and classrooms, as well as others distributed anywhere around the world. The supporting technology created by the WeDigBio organizers includes the WeDigBio website (http://wedigbio.org), which features a dashboard to visualize event-wide transcription progress and resources for onsite event hosts. WeDigBio also uses Sococo, a virtual space in which scientists and public participants interact, and Libraries of Life, an augmented reality mobile app programmed to launch a 3D model of a specimen when the WeDigBio logo is in the mobile camera's field of view. The 2015 WeDigBio event engaged users in more than 125 countries to produce over 30,000 specimen transcriptions (Ellwood et al., submitted). While the initial focus of the WeDigBio events have been transcription of labels from specimen images, other digitization activities (e.g., digital imaging of specimens, georeferencing specimen collection localities) are viewed as in-scope for future events as supporting technologies and protocols are developed (e.g., Nelson et al. 2015).

To date, WeDigBio onsite events have occurred in a relatively small number of undergraduate, high school, and middle school classrooms using resources originally created for informal education settings. These resources included game boards for morphology bingo (looking for particular features in specimens), habitat bingo (watching for words frequently used in habitat descriptions), geolocator (mapping collection localities of specimens), and timeline tracker (marking collection years on a timeline with major exploration events also given). Each of these games was created to encourage deeper engagement with the specimens and their label data as the participant transcribed. In an informal education setting, the results of these games are used to award small prizes (often chocolate). For example, the event host might ask who transcribed the earliest-collected specimen after a half-hour of transcribing. In an analogous use of the game card in formal education setting the instructor can prompt a discussion of the changes to collecting specimens between the earliest collection year and the latest (which could involve, e.g., changes to transportation to collecting sites) and how data is shared.

The transcription platforms involved in WeDigBio have introduced useful flexibilities to the circumscription of specimen sets (called "expeditions" by several platforms) to be digitized, opening new opportunities for use of the activity within classrooms. For example, the transcription platform Notes from Nature (http://www.notesfromnature.org) hosted a "WeDigFLPlants' Milkweeds of Florida—Monarch Butterfly Food Plants" expedition that was used during a herbarium outreach activity at the St. Marks National Wildlife Refuge's Monarch Butterfly Festival. In another example, a "Fall Flowers of Alachua County, Florida" expedition was completed during a science festival at the Florida Museum of Natural History (an institution found in Alachua County). Partnering between biocollections and local teachers in the creation of expeditions could result in lesson-plan-relevant digitization activities, perhaps in combination with field trips or classroom visits by local scientists or amateur enthusiasts. WeDigFLPlants, the source of both of the example expeditions, is a partnership between the Florida Native Plant Society and Florida's herbaria to digitize specimens collected from that state. The partnership has the potential to dovetail with the education goals of the Florida Native Plant Society by giving the education ambassadors in their 37 chapters a new classroom activity to support.

**Conclusion**

For natural history educators, effective engagement with K-12 educators involves a site-specific knowledge not only of curriculum and pedagogy (as indicated in other sections of this paper), but also an understanding of local factors that enable and constrain the rapid uptake of technology and applications. In this chapter, we introduced some overarching factors related to current K-12 education as well as presented a selection of promising practices that natural history educators will want to consider in program design, outreach, and evaluation. We also shared details relating to WeDigBio, a project that reflects many of the considerations outlined in this chapter, and successfully engaged educators and K-12 learners. Schools are highly complex systems in which thoughtful collaboration and sustained relationships can yield deep and meaningful integration of digitized specimens into STEM learning.

## Chapter 4
## Lessons learned from successful K-12 educational outreach using biological collections

### Introduction

The inclusion and integration of educational outreach-based activities are critical components for developing a compelling and successful broader impact statement for natural history collections' digitization proposals. In this chapter we provide a workable definition of outreach and present a framework for developing a successful outreach program. Finally, we highlight a case study outlining successful implementation of collection-based NSF funded outreach projects involving high school science teachers. As this publication focuses on digital biological collections, we offer a case study and lessons learned through outreach offerings focused on biological collections.

Outreach represents an important link between scientists and society. The practice of outreach involves extending services to those in need to facilitate the transfer of knowledge to diverse target populations (Kurpius & Rozecki, 1992). Scientists at academic institutions, government agencies and museums often collaborate to deliver outreach programs in K-12 educational settings with the goal of improving science education and broadening participation in science. Collections outreach allows for a link between learners and natural history collections in addition to formal field trips and visits to the institution by learners. It is important to recognize that both audiences have information to share with each other. Natural history collections personnel serve as sources of expert knowledge while bringing novel concepts and field-specific insights to K-12 learners. Educators and K-12 learners help outreach professionals recognize the needs of real-world learners and foster communication of science with those outside their field of study.

### Case study: a successful outreach program involving biological collections

Dr. Marc Cubeta, Professor of Entomology and Plant Pathology at North Carolina State University (NCSU), along with his colleagues Dr. Larry F. Grand and Caroline Vernia, has offered educational outreach workshops to high school teachers for five years. The workshop was entitled "Exploring Fungal Biodiversity, One Rotten Log at a Time" and was conducted at the Larry F. Grand Mycological Herbarium at NCSU. Initial funding from the National Science Foundation Advanced Digitization of Biological Collections Program drove the genesis of this educational outreach effort. The primary outreach objective of this project was to develop an educational workshop for biology teachers of underrepresented and low socioeconomic status high school students in North Carolina (NC). The workshop was developed based on the premise that high school teachers have limited time (usually less than one week) to teach about fungi as isolated taxonomic units. However, fungi can be effectively used to develop active experiential and inquiry-based learning assignments in science curricula and illustrate key scientific concepts central to chemistry, cellular biology, ecology, evolution, and genetics. In recent years, Cubeta and his team, which included graduate and undergraduate students, have expanded and revised their high school science teacher workshops. These outreach efforts were associated with National

Science Foundation Thematic Collection Networks (TCNs), namely, The Macrofungi Collections Consortium and The Microfungi Collections Consortium. Additional outreach components included, 1) providing educational opportunities for environmental science teachers and pre-service teachers and 2) expanding the program to engage pre-service teachers in states beyond NC at Middle Georgia College with the assistance of his colleague Dr. Sharon Mozely-Standridge. The title of the workshop was also revised to more accurately reflect workshop content (e.g. “STEM Educational Module Development Workshop: Fungal Biology and Biodiversity). Workshop participants were chosen based upon responses to questions on an online registration website. When choosing from the list of applicants, the workshop organizers attempted to maximize the types of schools represented and made sure participants had support from their administrations. Typically, we requested that interested teachers provide a brief statement and that they answer questions about their career goals and motivation for participation. Five to eight teachers were selected on a competitive basis for the workshop and a $500-750 stipend was provided to each teacher. In addition to monetary compensation, teachers who attended the workshops often received professional development credits from their respective schools. The workshops provided a framework that empowered teachers to promote greater student initiative and leadership in developing research questions and encouraged the use of inquiry-based, experiential learning investigations. Teachers who participated in the workshop developed activities that were peer-reviewed by other workshop participants and aligned with applicable learning frameworks for use in their classroom.

**Lessons Learned**

Many lessons were learned through five years of workshop implementation and iteration. First, we learned that it was important to have a well-structured team. Two important members of the team were an outreach coordinator who managed day-to-day planning activities and handled administrative tasks and a teaching partner to share the instructional load during the workshop. It was critical to have a classroom teacher on the team to establish contacts and strengthen relationships with schools and teachers and to serve as an expert on the educational culture of high school teachers. The teacher also served as a direct connection to the school administration and handled professional credit incentives offered to workshop participants. It was also important to establish credibility through face-to-face interactions with administrators and teachers prior to conducting the workshop.

Creating an outreach plan with reasonable parameters was a critically important lesson learned. Several times we attempted to align his workshop with the annual meeting of the Mycological Society of America that were held in states other than North Carolina. However, he found it was more challenging to recruit workshop participants at a distance. With no specific teacher connections, the interest level was too low to conduct and sustain a workshop. Besides challenges with recruitment, logistics regarding equipment and environmental conditions were much more difficult than at a local scale. After attempting to hold workshops in other areas several times, we concluded that remaining in one’s own local area or expanding to states that are in close proximity to North Carolina made recruiting participants much more likely and workshop organization much more reasonable.

Another lesson was learned when evaluating the effectiveness of incentives. Evaluations showed that the $500-750 stipend was important to many workshop participants for various reasons. For instance, one teacher mentioned that she had to request time off from their summer job to attend the workshop; the stipend helped alleviate concern about lost pay. In addition to the stipend, teachers were thankful for the opportunity to earn professional development credit. In some states, such as North Carolina, teachers are required to complete professional development and training to renew their teaching licenses. The workshop, while a unique learning experience, was also utilitarian in this way. Finally, gaining actual scientific experiences such as collecting and identifying fungal specimens was an incentive in itself, as teachers believed it provided them with more scientific credibility in their teaching practice.

We found that evaluation was important both during and after the workshop. He administered an open-ended response questionnaire at the midpoint of the workshop and used the results to make immediate changes for the second half of the workshop. A similar questionnaire that included Likert scale items administered at the end of the workshop also uncovered useful information that could be used to plan future programs. The Likert scale items required participants to “disagree”, “agree”, etc. with statements about the workshop. At the end of a program, it was important to reassess and reflect on what could make that program more effective or broaden its reach. The following are considerations after the completing several successful rounds of his program.

Transcription platforms such as WeDigBio and Notes from Nature can be useful resources to enrich outreach and provide opportunities to additionally highlight the digital aspect of modern collections. We recommend incorporating transcription platforms into digitized collections’ outreach. Resources like these are meaningful in that they relate to something that scientists actually do. These platforms can also help illustrate concepts of ecology, classification and digitization, which may be otherwise be challenging to convey through traditional lectures and assignments. Incorporating these resources into a collections-based workshop broadens the practicality of lesson planning for schools without access to physical specimens. Including transcription platforms in outreach projects under digitization grants provides a cohesive link between broader impact statements and digitized collections.

The team encountered challenges including time and logistical constraints. Perhaps the most important lesson learned through years of workshops is to define realistic goals for the project. When trying to secure funding and maximize the real-world broader impacts of outreach projects it is tempting to propose more ambitious goals than what is possible. Focusing on the local scale with a relatively small workshop allowed us to be successful. However, even with an outreach coordinator, the team struggled to find time to publish learning modules and perform related research tasks to this end. What may seem like a small project often has unanticipated, time-consuming complications and consequences.

When writing digitization grant proposals, mindful outreach projects make for successful broader impacts in science education. One such outreach project is the teacher training workshop. Through planning and facilitating five years of workshops, we learned the following lessons, 1) assemble a well-rounded team, 2) start local and stay at a realistic scale that focuses on high quality impacts, 3) provide utilitarian incentives to participants, 4) value and respond to participant evaluations, 5) familiarize yourself with the national and state science standards appropriate for your project, 6) consider including a transcription platform, and 7) anticipate complications. Following these guidelines and lessons learned will help structure successful collections-based outreach, strengthening the link between scientists and society.

# Chapter 5
# Broadening Participation

## Rationale

*What is Broadening Participation?*

The term broadening participation refers to reaching out to individuals from a wide range of underrepresented groups. Groups considered underrepresented in STEM fields in the United States include (but are not limited to) racial/ethnic minorities (such as Native Americans, Blacks/African Americans, Latinos/Hispanics, Asian Americans/Pacific Islanders), persons with disabilities, and women. This definition also includes people from low socioeconomic backgrounds and first generation college students (Table 1, Espinosa & Rodríguez, 2013). Broadening participation does not stop with the individual. Projects or entities looking to broaden participation can also target schools, institutions, and organizations that serve underrepresented populations. There are also geographical areas known throughout the country that do not have appreciable participation of individuals, such as many very rural or urban areas (Broadening Participation at NSF, 2008). To learn more about the current diversity of the STEM field we recommend the 2013 NSF Report Women, Minorities and Persons with Disabilities in Science and Engineering.

*Why Should We Care?*

Science has traditionally been predominately white and male, with Native Americans, Blacks and Hispanics comprising 3% each of all employed scientists and engineers, but why is this a problem (Stage et al., 2013)? Motivations to increase diversity in STEM fields include a concern for equity and social justice –an ethical or moral platform. Many also point to the importance for increasing the pool of future scientists in a country with changing demographics. By 2050, 50% of the residents in the United Stated will be racial/ethnic minorities (Starobin et al., 2013). One of the more powerful rationales for increasing diversity is that it will diversify the types of experiences, perspectives, and cultural lenses that science has to identify, tackle, and communicate scientific issues (Medin & Lee, 2012). Also, if the scientific field more accurately reflects the population at large that likely would result in more community investment in science itself. With outreach at the K-12 level it is also important that scientists reach out to all people, because not only are they reaching future scientists, but also future policy makers and citizens. Having a better informed public with positive associations towards science means more public support for science. These reasons tie directly back to sustainability of science - an arguably essential issue.

*Current Status in Collections*

In the preface of this document we summarized 11 current programs and projects that are using digitized collections with K-12 audiences, and less than half of them have purposely included broadening participation as one of their goals in their resource design, or target audience. Our community is not alone in its abysmal performance in broadening participation. For example, a random sample of 280 awards was analyzed from the NSF Division of Environmental Biology, which revealed that broadening participation was the least often addressed type of broader impact (Watts et al. 2013). The bottom line is we can do much better.

| Types of audiences | Types of organizations |
|---|---|
| Women and girls | Urban |
| First Generation College | Rural |
| Lower socio-economic status | Faith-based schools/churches |
| Urban | Schools in Hospitals |
| Persons with disabilities | Schools for Deaf & Blind |
| Rural | Alternative Schools |
| Underrepresented minorities | |
| English Language Learners | |

*Table 1: Possible communities to target for Formal and Informal education.*

**Opportunities to Broaden Participation with Digitized Collections**

*Challenges with Traditional Brick and Mortar museums*

Many individuals do not have access to brick and mortar museums. People are limited by geography, i.e., many cities and towns simply are not fortunate enough to have a museum. Many people also lack transportation or leisure time to visit their local museum or are physically limited due to their health (hospitalization) or incarceration. There can also be financial, social and cultural barriers that keep people from visiting their local museums. Additionally, exhibit staff are space-limited, and can only incorporate a small fraction of a collections' holdings into public exhibits. Digitizing and sharing digitized natural history collections data and images online opens up a new world full of possibilities and possible uses, and increases access for many marginalized communities.

*Advantages of Digitized Collections*

Online collections have many advantages over those exclusively in brick and mortar museums including the following: increased *universal* access, access to entire collection (or an infinite number of curated sets), improved searching within collections via online databases, improved ability to provide context with objects, ease in customizing learning environment, engagement with multiple learning styles and audiences (Table 2), scalability of images, multiple entry points into biological content (i.e. technology, art), and relatively lower cost. Online resources also provide more opportunities for natural history collections to be used as a resource for projects like science fairs, scouts, or 4H, or be incorporated into a school curriculum.

*Challenges and Considerations*

Online resources have drawbacks to consider, especially when your goals are to reach underrepresented groups with your resources or activities. For example, not everyone has access to the internet. Many rural communities are still without reliable Wi-Fi (Johnson et al., 2016). A solution to this barrier is to provide printed alternatives to any online resources. Another option is to connect with libraries and community centers which may provide free internet access. Many families do not have access to computers in their homes, and many children from lower socioeconomic households access the internet only through mobile devices. One potential solution for this barrier is to create resources that are both mobile friendly and device agnostic. Creating digital libraries from natural history collections has the potential to create an information overload, making users feel overwhelmed or confused. A solution to this issue is to make sure your online resources do not exist in a void – make sure there is context and a clear narrative available. It is also important to work with the community you are targeting when developing resources to make sure that the narratives and context you are creating are relevant, engaging, and useful.

One potential barrier specific to formal education is limited access to web resources through filtering and blocking technologies. Although the majority of schools now provide computers and other hand-held devises connected to the internet, they often limit their use in an effort to prevent student access to inappropriate material (Wells & Lewis 2006). It is not safe to assume that teachers and students will be able to access your online materials because school filters are very restrictive. Some ways around this barrier are to use already approved channels of communication (such as http://www.teachertube.com/), or to work with local school administrators or policy makers to obtain approval for your online resources. Another option would be working with a local resource specialist within the school district.

| **Type of Activity or Resource** | **Audience** |
|---|---|
| Videos with captions | Auditory impairments |
| Images | Non-verbal learners, people with language delays |
| 3-D printing | People with visual impairments |
| Counting and sorting tasks | People on the autism spectrum |
| Mobile optimized resources | People without access to desktops or laptop and with visual/ hearing impairments |

*Table 2: Examples of different resource types and applicable audiences*

**Recommendations**

*Identify and Connect With Your Audience*

One of the first steps when engaging in broadening participation is to identify an audience. Begin that process by asking the following: "Who is most likely to benefit from my resources, activity, or program? How can we make this relevant to their daily lives?" Scale of the audience should also be considered. It is best to start small. For example, focus on one school/organization within the targeted community and build up.

Once you have identified the appropriate audience, the next step is to begin building a healthy relationship. Pathways into different communities have already been established between many schools, organizations and museums which may save time and provide valuable insight. One resource that is exists is Museum and Community Partnerships: Collaboration Guide and Additional Resources created by the National Informal STEM Education Network (NISE).

If pathways do not already exist, then the next step is to identify community leaders, school supervisors or other individuals who already hold a leadership position within the targeted community and start a dialog. Personal emails are best when first advertising a resource or service. It's easiest to begin marketing within school systems because they already have the communication infrastructure. Focus on leaders in the school who can help push the message across the school or district: guidance counselors, administrators, and content specialists. They will be able to spread the word to people who trust them, and they can offer other avenues for advertising (newsletters, listservs) that a simple google search might not reveal. Keep in mind the aim is to build a mutually beneficial relationship, where the community is actively involved and engaged in the scientific process. Inquiry is key here; ask as many probing questions when building a relationship with the community Aim to connect the target audience with real world outcomes of the project. For example, look at how the project may factor into potential careers for community members, improve health, or how the environmental change may affect them. Consider connecting with your community through a variety of avenues, such as art, and talking with parents and or locals as Traditional Ecological Knowledge (TEK) may contradict sentiments being shared.

*Considerations to Increase Accessibility*

Universal design should always be considered when creating new online resources. Universal design refers to a broad-spectrum of concepts meant to produce products, resources, and environments that are inherently accessible to everyone regardless of age, gender, socio-economic status, or disability status. Examples of considerations of universal design for online resources include designing applications and websites by providing a text equivalent for all non-text items, provide choices in features and different ways that tasks can be accomplished, create content in multiple language and providing captions or transcripts for video and audio clips. Find more information about universal design in Universal Design for the Digital Environment: Transforming the Institution.

**Case studies: Examples of successful programs and projects**

**Example 1:** *iDigFossils: engaging K-12 Students in Integrated STEM via 3d Digitization, Printing, and Exploration of Fossils*

**Funding Source:** NSF ITEST Program

**Project Summary:** The goal of the iDigFossils (http://www.idigfossils.org) project is to extend understanding of STEM learning through K-12 STEM paleontology. The project's team consists of K-12 teachers, museum professionals, 3D digitization industry experts, and STEM education scholars. The project plans to design, implement, and evaluate paleontology-focused curricula aligned with Next Generation Science Standards.

**Broader Impacts Summary:** (Taken from http://www.idigfossils.org/about/)

Research and education are seamlessly integrated in iDigFossils as we explore and define effective strategies and conditions for supporting equitable, highly engaged participation in integrated STEM to nurture student interest and identity in STEM. While solving paleontology-focused problems, K-12 students will be developing deep understandings of evolution,

biodiversity, and climate change.
The project will democratize access to rare fossils by contributing high-fidelity 3D models to Integrated Digitized Biocollections (iDigBio), the National Resource for Advancing Digitization of Biodiversity Collections funded by the NSF and Morpho Source. Our strategy will impact at least 45 teachers and over 900 students, many of whom are from groups currently underrepresented in STEM (Latinos, African Americans, and females). Harnessing the intellectual power and organizational resources of a flagship research university, a leading natural history museum, public K-12 schools, industry partners, and the national iDigBio project, our strategy will generate new opportunities to engage K-12 students in integrated STEM.
**Audience Selection:** iDigFossil purposely selected schools that had diverse demographics for participation in the program. The schools selected vary in geography, school grades, student and teacher demographics, school type (public, charter, private), and language. Schools were additionally selected through prior knowledge of teachers through previous projects. iDigFossil also worked within, and received recommendations from, school administrators. This project demonstrates the importance of working within the community to identify potential partners.
**Resource Design:** iDigFossil collaborated with faculty from the Department of Education at the University of Florida on the development of their curricula. They also plan to have teacher-directed modifications of all activities in order to make appropriate accommodations for different audiences. All teachers participating in the project will receive a kit that includes all of the resources needed for the activities. Teacher training will also be provided in the form of workshops. The workshops will cover content (in paleontology- interdisciplinary), pedagogy (how they should teach) self-efficacy (building confidence in technology), and standards.
**Recommendations from the Project:**

- Start small. Building relationships and trust in the K-12 school system takes time.
- Create activities that align with the standards of your target school audience.
- It is important to find someone who knows how to do evaluations, and you should consider evaluation costs in your proposal.

*Example 2: EPICC-Eastern Pacific Invertebrate Communities of the Cenozoic*
**Funding Source:** NSF, ADBC
**Project Summary:** EPICC (http://epicc.berkeley.edu/) is a collaborative project to digitize collections and we will be focusing on one of their outreach activities entitled Virtual Field Experience Project. EPICC leadership wanted to create educational modules that highlight real data, include big questions (global change) and educational standards. They also wanted to expand beyond just standalone modules. The collections that are being digitized are from California and the Pacific Northwest. The Virtual Field Experience Project will highlight the entire process from field to database to research to show the entire data life cycle for paleontologists.
**Broader Impacts Summary:** (Taken from: Estes-Smargiassi et al. GSA 2016, Increasing diversity and sustainable workflows) The EPICC project will engage several underserved community colleges and a minority serving University. The project reaches at risk youths in the geoscience field, through an internship program for credit, followed by paid part time work, targeted specifically at underserved colleges and universities.

**Audience Selection:** The EPICC Virtual Field Experience project will be leveraging an existing audience from the website understandingscience.org and understandingevolution.org. They also plan to build their audience around the communities surrounding the scientists involved. Due to the nature of the resource (a freely available website) they plan on designing materials for both informal and formal educational audiences. Teacher professional development will be conducted with teachers from multiple areas that represent diverse populations. Virtual field experiences are naturally more inclusive and reach different audiences than traditional field experiences for students.

**Resource Design:** The project is currently considering accessibility issues during website development including translation of materials into multiple languages. They will also building off an existing audience and not "reinventing the wheel" for their resource by posting it as part of the new Understanding Global Change project which will be connected with the widely popular Understanding series. They will also be creating supplements to the website materials to target different underrepresented audiences.

**Recommendations from the Project**

- Don't reinvent the wheel. Partner with existing successful online platforms for new resources.

# Chapter 6
# Evaluation and Assessment

In previous chapters, we have emphasized the importance of defining your audience, identifying its needs, and having answers when asked “How do I know this will work?” or “Why should I use this in my classroom?” Engaging with your audience to learn more about their goals and challenges, trying out your activities with students to see how they work, and collecting evidence about learning gains or increase in interest are all activities formally known as “evaluation and assessment.”

## Evaluation Basics

In learning settings, assessment, evaluation, and research are related, but different enterprises. Evaluation provides evidence regarding the merit or value of a product, activity, or larger scale effort (e.g., a collections-based curriculum). *Front-end evaluation* takes place early in the project and focuses on identifying audience needs. *Formative or process evaluation* occurs during the development phase of a project and throughout implementation. Formative evaluation yields insight into what is working well and where adjustments should be made. *Summative evaluation* occurs at major milestones or near project end. Also known as impact or outcome evaluation, these evaluation efforts document project success, effectiveness, or impact.

While evaluation gathers data about a product, project, or program, assessment gathers data at the level of the individual. In formal K-12 settings, assessment tends to focus on factual knowledge and skill development. State and national standards such as the Next Generation Science Standards (NGSS) detail the concepts and skills deemed important within and across science domains and by grade level

. Assessment in informal learning settings tends to be more wide-ranging and includes interest in science, motivation to do science, and identity as a science learner in addition to knowledge and skills. The National Science Foundation (NSF) and the National Research Council (NRC) have developed frameworks for appropriate areas to measure when working in informal learning settings (see Table X).

| NSF FRAMEWORK CATEGORY | LSIE STRANDS |
|---|---|
| **Knowledge, awareness, understanding:** Measurable demonstration of assessment of, change in, or exercise of awareness, knowledge, understanding of a particular scientific topic, concept, phenomena, theory, or career central to the project. | **Understanding** (Strand 2): Come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science. |
| **Engagement, interest, or motivation in science:** Measurable demonstration of assessment of, change in, or exercise of engagement/interest in a particular scientific topic, concept, phenomena, theory, or career central to the project. | **Interest** (Strand 1): Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world. |
| **Skills related to science inquiry:** Measurable demonstration of the development and/or reinforcement of skills, either entirely new ones or the reinforcement, even practice, of developing skills. | **Science Exploration** (Strand 3): Manipulate, test, explore, predict, question, and make sense of the natural and physical world. |
| **Attitudes toward science:** Measurable demonstration of assessment of, change in, or exercise of attitude toward a particular scientific topic, concept, phenomena, theory, or career central to the project or one's capabilities relative to these areas. Attitudes refer to changes in relatively stable, more intractable constructs such as empathy for animals and their habitats, appreciation for the role of scientists in society, or attitudes toward stem cell research, for example. | **Identity** (related to Strand 6): Think about themselves as science learners, and develop an identity as someone who knows about, uses, and sometimes contributes to science. Also related to Strand (4), Reflection: Reflect on science as a way of knowing; on processes, concepts, and institutions of science; and on their own process of learning about phenomena. |
| **Behavior**: Measurable demonstration of assessment of, change in, or exercise of behavior related to a STEM topic. Behavioral impacts are particularly relevant to projects that are environmental in nature because action is a desired outcome. | **Skills** (related to Strand 5): Participate in scientific activities and learning practices with others, using scientific language and tools. |

Assessment is one tool that can be used in evaluation; like evaluation, it can occur during multiple phases of a project. Assessments administered at the beginning of a project can establish a baseline which then makes it possible to measure gains that might occur as a result of the resource you have developed. Observing learners as they work on activities or asking them questions are formative assessment techniques that provide insight into learners' interests and understanding. Formative assessment can also help you determine whether your resource is appropriate for the audience and identify ways in which it might need to be tweaked. Summative assessments such as student presentations and projects along with traditional worksheets and tests are a source of evidence regarding project effectiveness.

**Why is Evaluation Important?**

Evaluation, if done properly, helps ensure that you develop high quality resources and programs that will be used by the educational community. Seeking audience input early and refining your resource or program in response to feedback throughout development increases the likelihood that your project will meet a recognized need, be accessible and affordable, and be successfully implemented with your target group. While we emphasize the value of evaluation throughout your project, a well-designed summative evaluation that provides evidence that your resource or program produces positive outcomes (and under what conditions and with which groups) is important if you hope to have your efforts used widely. While anecdotal reports of success can aid dissemination, evidence that your resource or program can yield specific outcomes (e.g., learning gains aligned with standards) is especially important to educators in formal school settings. For this reason, federal agencies and other funding organizations often require an evaluation plan be included in a proposal; some programs also require that the evaluator be external to your organization as a way to avoid bias.

Considerations before you start

Look into standards. One of the first things you should do is think about your target age/grade level, whether you hope to work in formal or informal settings, and *how your resource or program aligns with standards*. With today's emphasis on accountability, your resource or program is unlikely to be used if it does not correlate well with the educational standards adopted in your community. Programs in informal learning settings such as after school organizations or museum camps are almost as likely to embrace standards as those in formal K-12 settings, and some—such as 4H—will have their own set of required standards, objectives, or goals.

Partner with educators early on. These professionals—whether based in formal or informal settings—will be able to help you set realistic goals and select appropriate standards and age/grade levels. They will also be able to provide practical advice about the length of lessons and curriculum units, feasibility of using technology, which grade levels or school types (e.g. magnet) may be most open to participating, times during the academic year when teachers might be most willing to explore a new resource or participate in professional development, and what kinds of incentives you may need to provide.

As mentioned above, evaluating your resource or program is essential, and doing so effectively will require cooperation from educators. If you hope to collect student data such as worksheets, test performance, or projects to measure learning gains, for example, you will need teachers' help. If you are planning to solicit feedback from educators about your resource or data about themselves, they should be alerted to that from the beginning.

Work with an evaluator. If you lack training or experience doing evaluation, we recommend that you consult with someone with evaluation expertise. The best time to begin working with an evaluator is when you are formulating the project with your educational partners. An evaluator can help translate your ideas into measurable goals and objectives, identify your theory of change, develop an evaluation plan that identifies what kind of data will be collected, how it will be collected, from whom and when, design data collections procedures (e.g., surveys, interviews, student work), analyze the data, and determine conclusions and recommendations. For complex projects with multiple partners and components (e.g., a curriculum with a website and app), the evaluator may create a logic model that describes how various project components relate to each other and to project objectives.

If you are working with educational partners, they are likely to have had some formal training in evaluation and assessment and so you may not need to look outside your team for evaluation expertise. Some museums have evaluators on staff, or educational staff with experience doing evaluation. You may also find evaluators in college/university departments such as education, psychology, and social science/policy. You also have the option to hire a professional evaluation service, although these can be quite expensive. You can find individuals and organizations that provide evaluation services through professional organizations such as the American Evaluation Association ( www.eval.org).

Become aware of regulations related to research and data. Both implementing a project with youth and evaluating it are subject to a variety of restrictions and regulations. If you are working in a formal K-12 setting, you will likely need your resource evaluated by an administrator or review board to ensure that it meets local educational standards and meets federal guidelines related to student privacy. The Family Educational Rights and Privacy Act (FERPA) is a federal law that applies to all schools that receive funds from the U.S. Department of Education. It protects the privacy of student education records, and allows parents and eligible students certain rights related to review, control and privacy of those records. Many out-of-school organizations have similar policies related to program quality and student data.

Also important is to decide early on whether anyone associated with the project intends to share any of the data collected as part of either implementation or evaluation in a research publication or at research conference. Generally, neither assessment undertaken as part of normal classroom activities or evaluation designed to improve or demonstrate program effectiveness are regarded as research because the data are collected for internal use. Sharing the data in a publication or conference presentation is contributing to a body of knowledge and thus constitutes research. Consequently, all procedures related to participant recruitment and data collection, storage, and security need to be reviewed by an ethics review board. At colleges and universities, these are often called Institutional Review Boards. Many school districts have their own in-house review boards as well.

Online platforms present special challenges and there are several federally regulated restrictions on the collection of personally identifiable information (PII) and data of students. It is the responsibility of the platform provider, the research team, the school district and the teacher to maintain familiarity and awareness of these regulations, including The Children's Online Privacy Protection Act (COPPA) and The Family Educational Rights and Privacy Act (FERPA).

The Children's Online Privacy Protection Act (COPPA) is a Federal Trade Commission (FTC) Rule designed to ensure that parents remain in control of personal information collected from their young children online. It applies to operators of websites or online services that collect, use or disclose personal information from children under the age of 13, and to operators of websites or online services that have actual knowledge that they are collecting personal information from users of another website or online service directed to children.

**Evaluation Phases** (this section could use subheadings but I can't decide on what evaluation model to use. Maybe someone on the team will have a good idea)
Identification of Objectives. Let's begin by assuming that you have conducted some sort of front-end evaluation or needs assessment that justifies your resource or program. This may be a review of the literature, an environmental scan (e.g., a review of currently available resources), or interviews or surveys of educators, administrators, or youth.

You should now begin to develop a conceptual model of your resource that outlines clear objectives and outcomes the means by which your objectives will be met; the more specific you can be about how your resource, activity, or program will cause the desired outcome the better. You may find it useful to bring in an evaluator at this point if you have not already done so.

Design of Evaluation Plan. The next step is to develop evaluation questions and define measurable outcomes. These outcomes may be aligned with learning standards, but there are many other possibilities including interest in or motivation to do science, a science identity, or appreciation of biodiversity or natural history collections, among others. Once you have defined your objectives, it is time to begin to develop an evaluation plan. This plan will outline what kind of data to collect to inform project development, track progress, and document success. The plan should also indicate when data will be collected, by whom, and how (e.g., interviews, surveys, observations, etc.). Of course, this plan may require modification as the project unfolds.

If you plan to collect data from students in formal K-12 settings or youth in organizations such as 4-H, this is the point at which you need to begin a conversation with administrators as you may need to have your procedures reviewed. Also, if there is a chance that you will use the data for research purposes, you will need to have your protocol reviewed by an ethics board so as to ensure that the rights and privacy of the research participants are protected. This process needs to be completed before you begin data collection.

Decisions made at this phase determine whether your efforts will yield information you can actually use. Therefore, it is important for your team to have a clear idea of why you are doing evaluation in the first place. Are you primarily interested in getting feedback to help you improve your resource? Or are you mostly interested in collecting data to demonstrate that your program or resource produces specific kinds of gains—learning or other? Or perhaps you are interested in understanding better the means by which your program or resource produce different outcomes?

The complexity and—to some extent—the rigor of your evaluation depends on where you are in the development of your resource, the scope or your project, and your goals. If you are in the early stages of developing a classroom activity, for example, an appropriate evaluation might involve observing students and teachers do the activity then soliciting feedback from teachers and possibly students about what worked well and what did not. This formative evaluation would reveal whether the activity is appropriate for that grade level, a reasonable length given constraints of school schedules, viable given available technology, and more.

If you have already gone through this iterative process of pilot testing your activity (or other resources such as a website), it would be appropriate to do a more formal evaluation to document learning gains. In this case, you might ask teachers to do a baseline assessment of what students already know about the topic, embed assessments throughout the lesson, then conduct a summative assessment such as an objective test or project at the end. Teacher interviews or questionnaires could also provide helpful insights.

If your goal is to publish the results of your evaluation or have your project widely adopted as an “evidence-based” lesson or curriculum, you might use an experimental design with either a control group or comparison groups of comparable students exploring the same content via different methods (e.g., text). Moving your project into the realm of research thus transitions it from strictly evaluation (or assessment) to a more rigorous design. This also sets the bar higher for compliance issues, e.g., IRB approval.

Data Collection. Regardless of your how involved your evaluation is or where you are in your project, there are many methods and tools available for data collection (see Table X –lists concept mapping, interview, surveys, etc.). Outlining the advantages and disadvantages of each and the situations in which one or more of the methods would be most appropriate is beyond the scope of this white paper; however, you can find much discussion of these and related issues such as validity, reliability, sampling, and bias in the resources listed below. That said, there are some simple guidelines to consider. One is that direct measures of learning or other outcomes of interest are almost always more powerful than asking individuals to self-report. Another is that interviews and focus groups tend to yield richer data than surveys and questionnaires, but they also require a greater investment in time both in data collection and analysis.

A critical factor to consider when choosing your evaluation methods is who will be providing the data (e.g., students, teachers, administrators, etc.). There are developmental constraints on using some methods with young children, for example, and time constraints may limit your options when collecting data from educators and administrators. Another key consideration in selecting your methods is who will be collecting the data. Depending on your project, it may be best if someone closely aligned with your project (e.g., a classroom teacher) collect the data; in other cases, you may get better responses if you employ someone external to the project.

Data analysis. The next step in the evaluation process is analyzing the evaluation data. The amount of time this will take ranges widely and varies with your evaluation methods. Some kinds of data such as that derived from interviews or written responses to open-ended questions will need to be coded or categorized to be quantified in order to summarize and interpret results, while online survey software can automatically produce reports.

Dissemination of Results. Once the data are analyzed, it is time to prepare a report. Again, the nature of this report will vary depending on the scope of your project and your evaluation goals. An evaluation report might be as simple as a few pages describing the methods, a summary of results, conclusions and recommendations. Alternatively, the report could take the form of a research paper, or even a lengthy document with extensive graphics running 50 pages of more. More often than not, evaluation reports are used primarily for internal purposes or as a requirement by a funding agency and hence are not publically available. However, in recent years, NSF has funded the Center for Advancement of Informal Science Education at the University of Pittsburgh to create and maintain a database (www.informalscience.org) of evaluations of informal science education projects. This is a good resource to learn more about different types of evaluation and methods of reporting.

### Common Evaluation Pitfalls to Avoid

There are a number of common mistakes to avoid when evaluating your project.

- *Waiting until the end of the project to begin to think about evaluation.* Probably the most common mistake is waiting too long into the project to begin evaluation. As we have mentioned previously, soliciting formative feedback throughout the project can greatly improve your product. If you wait too long, it can be costly or difficult to make necessary changes. If you wait until the end of the project to collect only summative data, you not only miss the opportunity to improve your resource, but you may lack the necessary permissions (e.g., informed consent) to collect data or use data already collected.

- *Lack of alignment between assessment tools and objectives.* Another common pitfall is choosing assessment tools that do not assess the knowledge, skill, or other outcomes the resource is designed to promote. For example, if your activity involves creating range maps of a species based on information found in a database, appropriate assessments might focus on skill in selecting data or how to read a range map rather than an objective test about DNA. Using pre-existing assessment tools such as unit exams associated with textbooks or state exams aligned with the NGSS can be both efficient and compelling, but it only makes sense to do so if your resource relates to the items on those tests.
- *Poorly formulated items*. The advent of online survey software has made it possible for virtually anyone to create a survey that looks quite professional, yet is deeply flawed due to the questions asked. Common mistakes include asking vague questions, leading questions, and questions that include two issues in the same item (e.g., Please rate your interest and awareness in mollusks after this activity?)
- *Tools or methods are not appropriate given the context or participants' age*. Those who work in collections typically have extensive science backgrounds, but their educational experiences are limited to formal classroom settings and older youth or college students. As a consequence, the natural "go to" means of assessing outcomes may be objective tests. While tests may be the best tool in some situations, they may not align well with the goals embodied in informal education settings and may prove entirely invalid and unreliable when used with young learners.
- *Evaluation design that does not permit causal attributions of change*. We often develop resources that we know "work" in that they engage the target audience and post-activity measures suggest participants showed gains related to a desired outcome. Evidence of effectiveness is more compelling, however, if one can compare post-activity performance to baseline data collected prior to the activity. An even stronger evaluation design would compare performance between those who engaged in your activity to those of a control group—a comparable group of individuals who did not.

# Chapter 7
# Finding Support for K-12 Outreach Projects

Typically only a limited amount of funding can be budgeted within collections digitization and research grants proposals for K-12, mostly as part of the Broader Impacts plans and activities. It is a delicate balance to know how much to include in these; and there is no set amount. Of relevance here, however, you may find that you become really passionate about Broader Impacts and K-12 and want to do more. In cases such as this, you will need to find other sources of support.

## NSF (National Science Foundation)

If you start small, you may want to contact your Program Officer to explore the possibility of a supplement to your existing award. These supplemental requests can build upon, but must be outside the scope of the K-12 BI activity that you originally proposed. If the idea is unrealistic given budgetary constraints in the research directorates (e.g., BIO, GEO), you might consider EHR (Education and Human Resources). Depending upon how your structure your program, you can look for funds, and tailor your project to the goals and objectives of EHR programs. Several of these include AISL (Advancing Informal STEM Learning) for museum and out-of-school learners, DRK-12 for innovative curriculum development, and iTEST for technology mediated learning. If you go this route, be advised however that it is not for the novice or amateur. These EHR programs are primarily focused on advanced learning research using these programs. In these instances, it is wise to partner with a professor or other professional (e.g., museum educator) who is well versed in the design, implementation, and evaluation of learning research projects.

## IMLS (Institute of Museum and Library Services)

IMLS goals focus on achieving positive public outcomes for communities and individuals; supporting the unique role of museums and libraries in preserving and providing access to collections and content; and promoting library, museum, and information service policies that ensure access to information for all Americans. This agency's programs support both libraries and museums in three main programs:

***National Leadership Grants for Libraries.*** National Leadership Grants for Libraries (NLG) support projects that address significant challenges and opportunities facing the library and archive fields and that have the potential to advance theory and practice. Successful proposals will generate results such as new tools, research findings, models, services, practices, or alliances that will be widely used, adapted, scaled, or replicated to extend the benefits of federal investment. For the NLG program, applications must designate one of the following project categories:

- Community Anchors: Advancing the role of libraries as community anchors that provide civic and cultural engagement, facilitate lifelong learning, promote digital inclusion, and support economic vitality through programming and services;
- National Digital Platform: Creating, developing, and expanding the open source software applications used by libraries and archives to provide digital content and services to all users in the United States.

- Curating Collections: Impacting shared services for the preservation and management of digital library collections and content across the country

***Laura Bush 21st Century Librarian Program.*** The Laura Bush 21st Century Librarian Program (LB21) supports professional development, graduate education, and continuing education to help libraries and archives develop a diverse workforce of librarians to better meet the changing learning and information needs of the American public. LB21 grants also must designate their linkage to either Community Anchors, National Digital Platform, or Curating Collections.

***National Leadership Grants for Museums.*** National Leadership Grants for Museums support projects that address critical needs of the museum field and that have the potential to advance practice in the profession so that museums can improve services for the American public. National Leadership Grants for Museums has three project categories:

- Learning Experiences: Providing high-quality, inclusive educational opportunities that address particular audience needs;
- Community Anchors: Strengthening museums' capacities for civic engagement, these projects contribute to the creation of livable, sustainable communities; and
- Collections Stewardship: Addressing state-of-the-art collections care and collections-information management, curation, preventive conservation, conservation treatments, database creation and enhancement, digitization, and the use of digital tools to facilitate discovery and deepen engagement with museum collections

Because IMLS' mission is to inspire libraries and museums to advance innovation, learning and civic engagement, the agency also occasionally offers special programs that may be relevant to the digitized specimen collections community. IMLS offers two grant cycles per year and submissions to each cycle begin with a two page pre-proposal. Proposers with favorably reviewed pre-proposals are asked to submit full proposals for funding consideration. Read more about IMLS current funding opportunities at http://imls.gov

**US Department of Education**. The Institute for Education Sciences (IES) at the U.S. Department of Education has several programs that may be appropriate for projects that include research related to digitized specimen use. IES programs center on three research objectives:

1. Develop or identify education interventions that enhance academic achievement and that can be widely deployed;
2. Identify what does not work and thereby encourage innovation and further research;
3. Understand the processes that underlie variations in the effectiveness of education programs, practices, and approaches.

IES encourages researchers to develop partnerships with education stakeholder groups to advance the relevance of their work and the accessibility and usability of their findings for the day-to-day work of education practitioners and policymakers. In addition, researchers should disseminate their results to a wide range of audiences that includes researchers, policymakers, practitioners, and the public. IES grant programs are excellent opportunities for collections providers to partner with education researchers and practitioners.

IES seeks to improve the quality of education for all learners-prekindergarten through postsecondary and adult education-by advancing the understanding of and practices for teaching, learning, and organizing education systems. By identifying what works, what doesn't, and why, the goal of this research grant program is to improve educational outcomes for all students, particularly those at risk of failure. IES research programs use a topic and goal structure to divide the research process into stages for both theoretical and practical purposes (each application must be submitted to one topic and one goal). Individually, the topics and goals are intended to help focus the work of researchers. Together, they are intended to cover the range of research, development, and evaluation activities necessary for building a scientific enterprise that can provide solutions to the education problems. Table 1 illustrates IES topics and goals.

Table 1. IES Topics and Goals (FY 2017).

| **Pertinent Programs and Topics** | **Research Goal and Description** |
|---|---|
| **Education Research Grants Program**<br>• Cognition and Student Learning<br>• Early Learning Programs and Policies<br>• Education Leadership<br>• Education Technology<br>• Effective Teachers and Effective Teaching<br>• Mathematics and Science Education<br>• Postsecondary and Adult Education<br>• Reading and Writing<br>• Social and Behavioral Context for Academic Learning<br><br>**Partnerships and Collaborations Focused on Problems of Practice or Policy**<br>• Researcher-Practitioner Partnerships in Education Research<br>• Evaluation of State and Local Education Programs and Policies | **Goal 1. Exploration**: Explore associations between education outcomes and malleable factors<br><br>**Goal 2. Development and Innovation:** Develop new or revise existing interventions (e.g., curricula, instructional approaches), determine usability and feasibility in authentic delivery settings (e.g., classrooms, museums), and carry out a pilot study of the intervention including the collection of student outcome data<br><br>**Goal 3. Efficacy and Replication:** Evaluate whether a fully developed intervention is efficacious under ideal conditions.<br><br>**Goal 4. Effectiveness:** Evaluate whether a fully developed intervention is effective when implemented under routine practice through an independent evaluation.<br><br>**Goal 5. Measurement:** Develop and/or validate new or refine existing assessments. |

| | |
|---|---|
| **Low-Cost, Short-Duration Evaluation of Educational Interventions**<br><br>**Research Networks Focused on Critical Problems of Education Policy and Practice**<br>• Exploring Science Teaching in Elementary School Classrooms | |

More information about the research goals can be found in the Common Guidelines for Educational Research (IES & NSF, 2013). This document is a valuable guide to shaping research projects for any federal research funding program.

Proposal ares for IES may change each year; the information here pertains to programs available in FY 2017, so be sure to review the latest topics and goals at https://ies.ed.gov/ncer/.

**Concluding comments**

In addition to the three entities described above, there are other agencies, foundations, and societies where you can look for additional sources of support. There may be some special programs in state or district school boards, local private foundations that support improvement K-12 teaching and learning, and some professional societies (e.g., the Paleontological Society) have small grants for education and outreach.

- Partnership organizations that support blended, flipped and virtual learning environments
- Research organizations interested in the efficacy of new classroom models
- Funding sources that support OER expansion within K-12 education
- Funding sources interested in the efficacy around new classroom models and the use of digitized content to support improved student outcomes
- What is needed to develop partnership and funding proposals to support outreach into the K-12 community?
- How to work with teachers and natural history museums to develop activities. What's the difference between public programming and exhibits?

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