INTEGRATING AUTHENTIC DIGITAL RESOURCES IN SUPPORT OF DEEP, MEANINGFUL LEARNING

January 2017

Prepared for the Smithsonian Center for Learning and Digital Access
By Interactive Educational Systems Design, Inc.
New York, NY

Smithsonian Center for
Learning and Digital Access

CONTENTS

Prior to the information age, only researchers and visitors to museums and archives had access to cultural artifacts, historical documents, and scientific specimens. Increasingly, these resources have become available in digital form to a much wider audience, offering a wealth of opportunities for study and application. Today, educational researchers and practitioners are developing effective ways to use digital resources—particularly those from authoritative sources—for learning that goes beyond familiarity with facts and memorization. Such learning, often described as *meaningful learning* or *deeper learning*, "enables critical thinking, flexible problem-solving, and transfer of skills and use of knowledge in new situations" (Darling-Hammond, 2008, p. 2)

Deep, Meaningful Learning Described

Learning that is deep and meaningful prepares students to use their understanding in new contexts by promoting transfer of knowledge and skills. A 2012 report from the National Research Council defines *deeper learning* as

> the process through which an individual becomes capable of taking what was learned in one situation and applying it to new situations (i.e., transfer)… . The product of deeper learning is transferable knowledge, including content knowledge in a domain and knowledge of how, why, and when to apply this knowledge to answer questions and solve problems. (NRC, 2012a, pp. 5-6)

Focusing specifically on problem solving, Richard Mayer (2002) writes similarly that *meaningful learning* "occurs when students build the knowledge and cognitive processes needed for successful problem solving." This in turn involves "devising a way of achieving a goal that one has never previously achieved"—in other words, transfer (p. 227). More broadly, Mayer's revision of Bloom's taxonomy identifies five categories of cognitive processes that are "increasingly related to transfer"

- *Understand*, including *interpreting*, *exemplifying*, *classifying*, *summarizing*, *inferring*, *comparing*, and *explaining*
- *Apply*, including *executing* and *implementing*
- *Analyze*, including *differentiating*, *organizing*, and *attributing*
- *Evaluate*, including *checking* and *critiquing*
- *Create*, including *generating*, *planning*, and *producing* (Mayer, 2002, pp. 228-231)

In other words, the more that learning activities promote these higher-level cognitive processes, the greater the likelihood that students will be engaged in learning that is deep and meaningful, involving transfer of knowledge.

Deep, Meaningful Learning in the Content Areas

Curriculum standards across the subject areas have been designed with a goal of helping students develop this kind of deep, meaningful understanding in the content areas, including the ability to apply key skills competently, flexibly, and creatively in a range of situations. The standards also promote college and career readiness. Standards include:

- The *Common Core State Standards for English Language Arts* call for students to be able to interpret a wide range of texts and other information sources in a variety of contexts, and to utilize that information for a variety of purposes.
- The *Next Generation Science Standards* call not only for deep understanding of disciplinary core ideas and crosscutting concepts, but also the ability to apply a variety of science and engineering practices, including planning and carrying out investigations.
- *National Core Arts Standards* connect artistic ideas and works with societal, cultural and historical context to deepen understanding.
- The *College, Career, and Civic Life (C3) Framework for Social Studies State Standards* is organized around the concept of inquiry, including the ability to develop questions and plan inquiries; apply disciplinary tools and concepts; evaluate sources and use evidence; and communicate conclusions and take informed action.

Use of Technology and Digital Resources to Support Deep, Meaningful Learning

Deep, meaningful learning also represents an important goal for instructional technology use and for the incorporation of digital resources into teaching. Guidelines from the International Society for Technology in Education (ISTE) call on teachers to "use their knowledge of subject matter, teaching, and learning, and technology to facilitate experiences that advance student learning, creativity, and innovation" and to build learning experiences "incorporating contemporary tools and resources to maximize content learning in context" (ISTE, 2008, Teacher Standards 1 and 2). In addition, the ISTE Student Standards call on students to become "knowledge constructors," meaning that they "critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts, and make meaningful learning experiences for themselves and others"—activities that are integrally connected with deep and meaningful learning (ISTE, 2016, Student Standard 3).

Along similar lines, explaining how students can become "21st-century learners," the American Association of School Librarians (AASL) describes such learners as using "skills, resources, and tools"— including digital tools and resources—to "[i]nquire, think critically, and gain knowledge" and to "[d]raw conclusions, make informed decisions, apply knowledge to new situations, and create new knowledge" (AASL, 2007, Standards 1 and 2). Thinking critically, drawing conclusions, making decisions, applying knowledge, and the creation of "new knowledge" all are aspects of deep and meaningful learning.

The Value of Authentic Digital Resources

In this paper we refer to images, video, audio, and text resources from a real-world source that connect to the content, literacy, and critical thinking skills of an academic subject area as *authentic digital resources*. For example, an authentic historical resource might be a document or speech, an image of an artifact, or a video of an event. Authentic science resources might include images of specimens and habitats, and documents created by scientists as part of their investigations (e.g., observations and lab reports). The value of these resources relies on the confidence teachers and students have in their authority.

Trusted resources can be particularly valuable for

the type of learning that is sometimes referred to as *authentic learning*, i.e., learning that involves "tasks . . . that resemble the challenges people face outside of school, whether as professionals, consumers, family members, or citizens" (Barton, 2001, citing Newmann et al., 1995; Wiggins, 1989). For example, in the case of history, such instruction "involves students directly in the analysis and interpretation of historical information," including "formulating historical questions or problems," "gathering information from a variety of sources," "evaluating the authenticity and reliability of sources," "comparing conflicting accounts," "taking the perspective of people in the past," and "connecting disparate pieces of information into coherent explanations" (Barton, 2001). Such tasks present clear examples of deep, meaningful learning involving problem-solving and transfer that can incorporate student interaction with authentic digital resources.

Note that our use of the term authentic digital resources has a different meaning than the term authentic materials has in language instruction. In that context authentic materials refers to texts arising naturally out of a social community, whose main purpose is to communicate meaning rather than to teach language (Thomas, 2014, p. 15, citing multiple sources; see also Al Azri & Al-Rashdi, 2014; Berardo, 2006; Tamo, 2009; Widdowson, 1990).

About This Report

The remainder of this report includes:

- *Approaches to Deep, Meaningful Learning Using Authentic Digital Resources*—This section describes three broad research-based approaches to integrating authentic digital resources as part of teaching and learning: project-based learning (PBL), guided exploration of concepts and principles, and guided development of academic skills.
- *Developing Repositories of Authentic Digital Resources and Related Tools in Support of Teaching and Learning*—This section summarizes research on how repositories of authentic digital resources can more effectively support teaching and learning, and describes the Smithsonian Learning Lab and its tools to help teachers and learners develop their own flexible and personalized approaches to learning.
- *Examples of Teachers Using Authentic Digital Resources to Support Deep, Meaningful*

Learning—This section presents seven examples of teachers and students using the authentic digital resources of the Smithsonian Learning Lab and describes how these examples support deep, meaningful learning.

● *Conclusion*—This section presents top-level findings and analysis of types of activities and instructional strategies that teachers have used to support deep, meaningful learning using the Smithsonian Learning Lab.

Research into deep, meaningful learning identifies several instructional approaches in which authentic digital resources can play a central role. These include project-based learning; guided exploration of specific concepts and principles; and guided development of key academic skills, including skills related to research, analysis, and synthesis of source materials.

Project-Based Learning (PBL)

Students can develop deep, meaningful learning through an application of knowledge and skills as part of a project. A research review published in 2008 found that well-designed small-group inquiry approaches, including project-based, problem-based, and design-based learning, "can be extremely powerful for learning" (Barron & Darling-Hammond, 2008, p. 13). For example,

> in the curricular reforms of the post-Sputnik years, initiatives using inquiry-based learning approaches . . . were found to produce comparable achievement on basic skills tests while contributing more to students' problem-solving abilities, curiosity, creativity, independence, and positive feelings about school. . . . This kind of meaning-oriented teaching, once thought to be appropriate only for selected high-achieving students, proved to be more effective than rote teaching for students across a spectrum of initial achievement levels, family income, and cultural and linguistic backgrounds. (p. 15, citing multiple sources)

More recent reviews of PBL research have also found "positive associations between a PBL approach and the development of knowledge and cognitive skills" (Condliffe et al., 2016; see also Holm, 2011). More specifically, studies have found that a PBL approach can also improve students' deeper learning. For example, one study found that middle school students experiencing a PBL curriculum "outperformed students in the comparison curriculum on outcome measures that were aligned to core ideas and science practices" (Harris et al., 2014, p. 2). Similarly, high school economics students whose teachers had received professional

development on a PBL approach outscored other students both on the Test of Economic Literacy (TEL) and on measures of "problem-solving skills and application to real-world economic dilemmas" (Finkelstein et al., 2010, p. xi).

Further, Barron and Darling-Hammond (2008) argued that in order for students to "gain vital media literacies, critical thinking skills, systems thinking, and interpersonal and self-directional skills," such skills need to be developed

> in the context of complex, meaningful projects that require sustained engagement, collaboration, research, management of resources, and development of an ambitious performance or product. . . . [T]here is a growing body of research indicating that students learn more deeply and perform better on complex tasks if they have the opportunity to engage in more "authentic" learning. (Barron & Darling-Hammond, 2008, pp. 11-12, citing Bransford, Brown, & Cocking, 1999, among others)

Part of the strength of project-based approaches is that they draw on the power of collaboration to support student learning. As explained in *Education for Life and Work*: "Deeper learning can be supported through teaching practices that create a positive learning community in which students gain content knowledge and also develop intrapersonal and interpersonal competencies" (NRC, 2012a, p. 7; see also AASL, 2007, Standard 2.1.4). Such deeper learning is fostered through "discourse, reflection, and shared experience" (NRC, 2012, p. 150). Project-based learning also provides opportunities for students to use digital tools and resources in "exploring real-world issues and solving authentic problems" (ISTE, 2008, Teacher Standard 1c).

Authentic resources can play a variety of roles in project-based learning. For example:

● Key concepts can be introduced and given context for students through exposure to relevant authentic resources. For instance, teachers can introduce the concept of bio-

diversity by showing images of many different varieties of birds or butterflies, then have students work in groups to compile their own examples of biodiversity and present them to the class.

- Students may be challenged to analyze and interpret authentic artifacts as part of the project learning process. For instance, students might examine contemporary portraits and political cartoons of U.S. President Andrew Jackson in order to better understand the variety of opinions about him in his own time, then select images to create hypothetical campaign posters for the 1824 presidential election, and explain how those images contribute to the impact of their posters.
- Authentic resources may be incorporated into culminating products that demonstrate student learning over the course of a project—such as through a multimedia presentation, a curated collection of resources, or student-developed artifacts modeled after those they have observed. For example, students creating a presentation on the Great Depression might include photographs, video news clips, and audio of interviews to communicate the human impact of the Depression. This aligns with the recommendation from ISTE that students "curate information from digital resources using a variety of tools and methods to create collections of artifacts that demonstrate meaningful connections or conclusions" (ISTE, 2016, Student Standard 3c) and the recommendation from AASL that 21st-century learners "Use the writing process, media and visual literacy, and technology skills to create products that express new understandings" (AASL, 2007, Standard 2.1.6; see also Standard 3.1.4).

Guided Exploration of Concepts and Principles

Deep and meaningful learning requires that students develop a profound and flexible understanding of core subject area concepts and principles. Such understanding is necessary for students to acquire the kind of "well-organized knowledge in a domain that can be readily retrieved to apply (transfer) to new problems in that domain" (NRC, 2012a, p. 82). Many such key concepts and principles are identified in subject-area state and national standards (e.g., practices, disciplinary core ideas, and cross-cutting concepts in the *National Science Education Standards*; disciplinary concepts and tools in the *C3 Framework for Social Studies State Standards*).

This kind of deep and flexible understanding can result when students investigate specific concepts and principles and apply their knowledge in multiple ways across multiple specific instances. For example, students may be taught a concept explicitly through direct instruction, then develop deeper understanding through "hands-on inquiries that engage students actively in using the material" (Darling-Hammond, 2008, p. 4).

In support of this approach, the ISTE Teacher Standards point out that "digital age learning experiences" can help to "maximize content learning in context" (ISTE, 2008, Teacher Standard 2). More specifically, deeper understanding can be facilitated in a variety of different ways across the subject areas by having students engage with authentic resources. For example:

- Students can approach the study of a literary work or informational text by examining primary source texts, photographs, artwork, and other resources that offer context (Abbott & Cohen, 2015, p. 10).
- Students can develop their knowledge of specific historical eras and geographic areas by "locating and assessing historical sources of many different types" (National Council for the Social Studies, 2013, p. 45).
- Students can gain a deeper understanding of artistic composition by examining multiple works of art "from any period in history, whether a photograph, sculpture, painting or cultural artifact" (Glatstein, n.d.).
- Students can gain a deeper understanding of scientific concepts through videos, audio recordings, and images of specimens on their way to constructing "explanations or designs using reasoning, creative thinking, and models" (NRC, 2012b, p. 44).

Such instructional uses align with research conducted for the Digital Public Library of America (DPLA) which found that K-12 teachers are interested in using authentic resources for "deep inquiry beyond simple illustration" (Abbott & Cohen, 2015, p. 20).

Guided Development of Academic Skills

As noted above, deep, meaningful learning requires the development of academic skills in the various subject areas that relate directly to the ability to

observe, analyze, and interpret texts and other authentic sources of information. For example:

- The *Common Core State Standards for English Language Arts* call for students to:
  - "Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words" (Reading Anchor Standard 7)
  - "Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation" (Writing Anchor Standard 7)
  - "Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism" (Writing Anchor Standard 8)
  - "Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations" (Speaking and Listening Anchor Standard 5)
- *National Core Arts Standards* call for students to:
  - "Perceive and analyze artistic work" (Responding Anchor Standard 7)
  - "Interpret intent and meaning in artistic work" (Responding Anchor Standard 8)
- Dimension 3 of the *College, Career, and Civic Life (C3) Framework for Social Studies State Standards* focuses on "the skills students need to analyze information and come to conclusions in an inquiry. These skills focus on gathering and evaluating sources, and then developing claims and using evidence to support those claims" (National Council for the Social Studies, 2013, p. 53). Among other relevant skills, these include the ability (individually and with others) to select and gather information from multiple sources, scaffolded as appropriate to match the capabilities of students from early elementary through high school.
- An essential science practice for K-12 classrooms identified in *A Framework for K-12 Science Education* and supported by the *Next Generation Science Standards* is Practice 3, Planning and carrying out investigations, including "careful observation and description [that] often lead to identification of features that need to be explained or questions that need to be explored" (NRC, 2012b, p. 59).

Such investigations can fruitfully include study of high-quality photographs, audio, video, and other authentic digital resources from the natural and scientific worlds.

Well-designed experiences with authentic digital resources provide opportunities for students to develop these skills while at the same time deepening their understanding of subject-area content. Such practices may include "close reading, considering sources in a broader historical context, and sharpening research information skills (like understanding and interpreting metadata)" (Abbott & Cohen, 2015, p. 20). These skills are also part of becoming a "knowledge constructor," which includes "plan[ning] and employ[ing] effective research strategies to locate information and other resources for [students'] intellectual or creative pursuits" and "evaluat[ing] the accuracy, perspective, credibility and relevance of information, media, data or other resources" (ISTE, 2016, Student Standards 3a and 3b; see also AASL, 2007, Standard 1.1).

Online collections provided by museums and other repositories of authentic digital resources represent a valuable and as yet largely underutilized resource for meaningful teaching and learning. Research provides insights into ways that such repositories can be organized to more effectively support K-12 teachers and students in integrating authentic resources as part of instruction.

Research-Based Recommendations

Utilizing Authentic Digital Resources across the Subject Areas

A 2015 report to the Digital Public Library of America (DPLA) found that digital resource repositories have most typically focused on history/social studies instruction in grades 4-12 (Abbott & Cohen, 2015, p. 8), including resources such as texts, photographs, and audiovisual recordings. At the same time, authentic resources can be used in a variety of ways that support learning in other subject areas, including English language arts and science (Abbott & Cohen, 2015, pp. 10, 15-16). Typical instructional uses of digital resources identified include the following:

- "To spark curiosity and discussion, at the beginning of a content unit, within direct instruction, and as a writing prompt
- "To deliver content in direct instruction, as part of a group of readings/viewings within a unit
- "To provide information that is useful in answering an inquiry in individual research or group projects
- "To build group projects outside the traditional research paper (such as exhibitions)" (Abbott & Cohen, 2015, p. 20).

Such activities have the potential to promote meaningful engagement of students with important content across multiple subject areas. More specifically, such uses of authentic digital resources align well with both project-based learning and guided exploration of concepts and principles from the academic subject areas.

Research conducted by the Smithsonian, including

a review of research literature and interviews with educators, found that many educators prefer that resources be interdisciplinary and/or multidisciplinary (Milligan & Wadman, 2015).

Involving Teachers

Too often, educational materials offered by digital resource repositories seem to reflect an imagined scenario in which teachers carry out instructional plans developed by others. However, the reality of how teachers use such resources is quite different. A 2012 review of literature conducted for the Smithsonian found that

> once content is taken from a site. . . , teachers use the content in a variety of ways—they need content that can serve them at any point in the learning cycle, from preparing a lesson at home, to pre-teaching, to delivering it in class for individual student interaction or group work. Finally, they use it for reflection and assessment. . . . The object itself, just like in a museum, takes center stage. How that object is interpreted begins with how it is annotated on the site, but ends with how the teacher and the students *use* it and analyze it in a given context. (Smithsonian Center for Education and Museum Studies, 2012, p. 11, citing Buffington, 2007; Leftwich & Bazeley, 2009; italics in original)

Rather than use lesson plans as is, teachers "tend to pick and choose the parts of the lesson plan that they like and find most useful" (p. 11, citing Horwitz & Intemann, 2007; Leftwich & Bazeley, 2009; see also Abbott & Cohen, 2015, p. 20; Milligan & Wadman, 2015). These findings suggest that "providing teachers with outlines, teaching ideas, suggestions, and Internet links is more valuable than trying to design a 'one-size-fits-all' lesson plan" (p. 11). Along similar lines, Smithsonian researchers found that in order to meet teachers' preferences, "resources should be adaptable in how they are used either pedagogically (for various learning or reading styles/abilities) or functionally (flexible to various presentation, sharing, and export formats)" (Milligan & Wadman, 2015).

The 2015 DPLA report makes a critical distinction between *engaging* teachers and *involving* teachers:

> Whereas teacher engagement positions teachers as *users* of resources, teacher involvement requires teachers to be *co-creators* through the process of contributing their lesson plans and activities, vetting resources contributed by other teachers, and providing feedback on the strategic direction of an education project. Such higher-level involvement is crucial to the production of education resources that resonate with teachers and meet their specific needs. (Abbott & Cohen, 2015, p. 13; italics in original)

In short, while digital resources should be annotated and organized to make them easy for teachers to use, digital resource repositories must also respect the expertise of the teacher in designing and adapting instruction that meets the needs of students, as well as contributing in other ways to development of authentic digital resource repositories.

A specific recommendation of the Smithsonian literature review was that filters should be provided "from a teacher's perspective" (Smithsonian Center for Education and Museum Studies, 2012, p. 24), including "established hierarchies and filters for grade level, standard, subject area, etc." (p. 13). Along similar lines, the DPLA report found that in order to be successful, digital resource repositories need to employ "an approach that gets education users to content as quickly as possible and gives them useful information about how that content fits into larger cultural and historical frameworks" (Abbott & Cohen, 2015, p. 3).

At the same time, the number of recommended resources needs to be manageable, with sufficient information to help educators quickly and easily identify which resources best fit their specific needs. The DPLA report found that in some cases, repositories offer educators so much content that "it is hard for them to know where to get started and how to quickly assess the depth and breadth of available materials related to specific topics" (pp. 5-6).

Effective Content Curation

The DPLA report calls for "curated resources that link digital content to relevant topics and particular uses" (Abbott & Cohen, 2015, p. 9).

Effective curation includes authoritative selection of resources that are authentic and closely connected to areas of real-world inquiry and investigation. It also involves ensuring the quality and usefulness of contextual information, or *metadata*, to accompany authentic digital resources.[1] Such contextual information may or may not be provided in "the title, description, or subject heading of a record, as well as in date and location fields" (pp. 12-13).

Research conducted with teachers found that

> the quality of contextual information that accompanies a primary source is the *most important factor* in its future classroom use. This context is useful as an introduction to a group of items, as well as at the item level, to give a sense of how a particular primary source fits into a specific historical moment and what relationships it shares with recognizable people, places, and concepts. . . . Teachers want to see how a primary source fits into their larger education unit so lots of context is useful for them. In contrast, students need enough context to start making connections but not a level of context that forecloses the possibility of questions, connections, and original thought (i.e., context shouldn't give students all the "answers"). (Abbott & Cohen, 2015, p. 20; italics in original)

As noted earlier, interpretation of metadata can be an important skill for students to develop in the context of learning to conduct research. Metadata can also play an important role in focused student exploration of concepts and principles by providing opportunities to investigate examples in depth. At the same time, the report cautions that "full metadata records from libraries, archives, and museums can be overwhelming, particularly for students" (p. 13).

Taken together, these findings underscore the importance of ensuring that digital resources are accompanied by information that is suited to the instructional purposes of the assignment and the capabilities of students, presented in a way that allows for modification in the classroom.

---

[1] "Metadata" is described in the DPLA report as "the descriptive information that travels with a cultural heritage item. It might include a title, description, creator, and more" (Abbott & Cohen, 2015, p. 12).

Aligning to Teachers' Instructional Objectives

An important part of making authentic digital resources useful is to present examples of how they might be adapted to the teacher's classroom. Key to this is incorporating these resources into lessons and activities that align to educational standards (Abbott & Cohen, 2015; Smithsonian Center for Education and Museum Studies, 2012).

In some cases, specific resources or sets of resources might be aligned to a relevant content standard. In the case of more skills-based standards, such as those in the *Common Core State Standards* and the *C3 Framework for Social Studies State Standards*, alignments are meaningful only in the context of instructional activities that describe student interaction with the resources (Abbott & Cohen, 2015, p. 12).

Promoting Interaction with Resources

Student interaction with authentic resources to promote meaningful learning is a priority for teachers. According to the DPLA report:

> [Teachers] wanted resources that provided students and teachers the chance to build something from the resource and/or its raw materials and share that creation. Instead of being given information, they want to actively engage with the resource content to generate something new. This is even better when students can interact with the resource to create something that teachers might use to assess their progress. (Abbott & Cohen, 2015, p. 19)

This kind of active engagement with resources can be fostered by providing appropriate tools and assignments for their use. Members of a teacher focus group reported that

> primary source analysis tools (like the genre-specific ones offered by the Library of Congress) were useful because they are topically agnostic but give educators a starting point for primary source analysis with students. Late middle school and high school students can also use these tools directly. Teacher guides might include standards-based skills to practice using a single primary source or multiple sources from the set (i.e., compare and contrast, finding evidence, analyzing data, etc.) or they might suggest activities like

discussion questions and writing prompts to guide student interaction with the sources. (Abbott & Cohen, 2015, p. 21)

Research conducted with middle school students and their teachers by the Smithsonian found that participants wanted to be able to interact with resources, including the ability to draw on objects and create unique collages from multiple images (Milligan & Wadman, 2015).

Teachers and Students as Creators

Teacher and student involvement can be taken to the next level by providing learners and educators with "increased means to select, assemble, save, and organize items for extended use and investigation," as called for by the 2012 Smithsonian literature review (Smithsonian Center for Education and Museum Studies, 2012, p. 24). This aligns with findings from the DPLA report, which stated:

> Increasingly, cultural heritage organizations want to put the power to create projects using primary sources in the education user's hands, whether they are annotating primary sources in iBooks (Library of Congress) or saving primary source items to public or private lists. (Abbott & Cohen, 2015, p. 15)

In support of this trend, the DPLA report found that K-12 teachers "valued the ability to interact with a resource by building their own projects" (p. 18). More specifically, prototype testing by the Smithsonian found that teachers value the ability to "save resources that they find useful" and "[t]he flexibility to organize and annotate resources according to their own schemas" (Milligan & Wadman, 2015).

A growing area of interest is empowering students to act as creators and curators of authentic resource collections. According to the DPLA report, "Instead of designing projects for teacher engagement, cultural heritage organizations are moving towards a model of direct student use" (p. 15). The report also found that teachers are "interested in the primary source sets as a starting point for student research but also wanted students to be able to make their own sets and share them via social media" (p. 23). Along similar lines, testing by the Smithsonian found that educators valued "[t]he ability to allow students to use the site and its tools as much as the

classroom educator" (Milligan & Wadman, 2015). Such practices align with recommendations from ISTE, which call for students to become "knowledge constructors," including curation of digital resources (ISTE, 2016, Student Standard 3).

Research by the Smithsonian Learning Lab also found that teachers and students wanted capabilities to personalize their resource collections, including adding external images, sharing collections through social media and email, and exporting collections (Milligan & Wadman, 2015).

The Smithsonian Learning Lab

The Smithsonian has spent more than a decade in active experimentation with webinars, digital badges, and other forms of learning far outside its museums' walls to support K-12 education. This objective was given formal shape in the Smithsonian's strategic plan for 2010–15, which set a goal to bring focus to and revitalize the institution's support for education (Smithsonian Institution, 2009).

Under this objective, the Smithsonian Center for Learning and Digital Access, which had for many years published lesson plans and a portal website to the Institution's instructional materials (SmithsonianEducation.org), launched a two-year research program to study its website and programs. This effort was guided by both institutional goals and a desire to be responsive to the needs of teachers and students as described in national education standards, which increasingly emphasize the incorporation of technology.[2] Working with members of an outside research team, the center conducted analysis of previous research, a literature review, guided investigation of teachers' responses to digital platforms and focus groups, and prototyping sessions focusing on what teachers want in terms of both content and format (see Milligan & Wadman, 2015; Smithsonian Center for Education and Museum Studies, 2012). The research effort led to recommendations and

specifications for a new "lab" website, culminating in the development of the Smithsonian Learning Lab (learninglab.si.edu), which was launched in beta in the fall of 2015 and officially in June 2016.

The Smithsonian Learning Lab is an online platform and toolkit that enables both teachers and students (as well as other users) to find, customize, and share digital museum resources with others. Many of the site's features are designed to support the learning needs of teachers and students in K-12 classrooms, higher education, and other blended learning environments. Resources and features of the Smithsonian Learning Lab that can help support meaningful learning experiences for students are described in more detail below.

Contents of the Learning Lab

More than 1.7 million authentic resources from the Smithsonian's 19 museums, nine research centers, the National Zoo, and other internal sources are currently available in the Lab. This number will continue to grow as more assets are digitized.

- The Lab includes images, artworks, specimens, artifacts, video and audio recordings, text from books, catalogues, magazine articles, blog posts, field books, diaries, and datasets. Smithsonian assets range vastly from ancient Chinese bronzes to recordings of the *Star-Spangled Banner*; from a billion-year-old micro-organism fossil to the Apollo lunar landing module; from the ruby slippers in *The Wizard of Oz* to presidential memorabilia. Only a fraction of the Smithsonian's assets are on display in the museums at any given time; hundreds of thousands more are available digitally through the Learning Lab.
- Resources in the Learning Lab include national icons, artifacts of everyday life, and specimens vital to the study and preservation of the natural world. Researchers study authenticity, significance, and value.
- Identifying and descriptive information (i.e., metadata), such as date, dimensions, and source, is part of each item in the database. Some items include extensive explanatory and interpretive text as well.
- Also included in the Learning Lab are materials created by the Smithsonian, including downloadable lesson plans, online exhibitions,

---

[2] See, for example, ISTE's standards for teachers and students (ISTE 2009, 2016) and the American Association of School Librarians *Standards for the 21st-Century Learner* (2007), as well as content-area standards in English language arts, science, and social studies (National Governors Association Center for Best Practices (2010); NGSS Lead States (2013); National Council for the Social Studies (NCSS) (2013).

games, and interactive activities. These teaching and learning materials include recommended strategies for working with museum collections in the classroom, ranging from the general ("Compare and Contrast") to the specific ("How to Look at a Portrait").

Creating and Adapting in the Learning Lab

Setting the Smithsonian Learning Lab apart from other digital repositories is its capacity for creating and sharing collections of resources. These collections can be augmented and personalized with digital tools to fit specific teaching and learning needs.

- Collections created by teachers tend to take one of three forms:
    - *Thematic aggregations*. While a search for resources on Maryland, for example, would yield 18,000 items, a teacher might narrow the search to "Colonial Maryland" to find 111 resources, then to "Colonial Maryland plantations" to make a collection with just three items.
    - *Teaching guides*. Teacher-developed collections may include one or many resources with an instructional strategy and recommendations for use in the classroom. Other teachers can use such collections as-is or modify them to fit the needs of their own students.
    - *Student activities*. These collections may include one or many resources and are written for the student, usually incorpo-rating questions to be answered, tasks to complete, details on which to focus, and problems to solve.
- Students can also create collections of digital resources. For example, a teacher might have middle schoolers create a collection of digital resources about a topic, then create a video arguing their position on an issue that incorporates evidence found in the resources.
- Teachers and students can add their own resource or resources they have found from other sources to collections they have created. These can include links, locally developed resources, quizzes, discussion questions, assignments, and student work.
- After resources have been added to collections, easy-to-use tools enable teachers and students to annotate the resources with "hotspots" and customized descriptions (for

example, by simplifying vocabulary). These features support student interaction with authentic resources to promote meaningful learning, as called for in the research-based recommendations earlier in this paper. These adaptations only apply to the copy of the resources in the specific collection where the change was made—allowing teachers and students to use the resources freely for their own purposes without affecting how they appear to other users.

Teachers can choose to publish their collections within the Learning Lab for use by other educators. Smithsonian developers have also created collections of resources for use within the classroom. As of January 2017, the Learning Lab included more than 1,500 published collections total, covering a range of topics, grade levels, subject areas, and instructional purposes. Many creators of collections also include other information, such as standards supported and recommendations/guidance for use with students. This feature allows teachers to align their use of authentic digital resources to their own instructional objectives, as called for in the research-based recommendations described earlier in this paper.

Such collections can be used in a variety of ways. They can be used as-is, or they can serve as models for others to adapt—for example, by deleting some items and uploading others, or by adding new guidance to students. They can also be embedded into a student, teacher, classroom, or school website, thus aiding communication between teacher and students while sharing evidence of learning with parents and community.

Searching for Resources and Resource Collections

Teachers and students can search for resources based on keywords, filtering by type (e.g., image, video, teaching materials) and/or provider (i.e., the Smithsonian museum or department).

Searching for collections in the Learning Lab is similar to searching for resources, but also includes filtering by subject, age/grade, and educational features (where relevant).

It is expected that more teacher-developed collections will be available for educational use over time. Teachers and students will no doubt

continue to conduct their own Learning Lab resource searches as well—for example, to help students develop research skills, as called for in the various content-area standards.

Search results display images rather than text. The searcher sees large thumbnails and brief descriptions, making promising items easy to spot without having to click to open each one in a new window. This helps streamline the search process.

Sharing Resources and Making Assignments

The Smithsonian Learning Lab is designed to facilitate both sharing and private use of resources and collections by teachers and students.

- Resources and collections can be downloaded or shared through social media, email, and publication in the Learning Lab website. They may also be embedded on other sites.
- The Lab's structure simply but clearly delineates private collections, which only the user can see or share via URL, and public collections accessible to anyone. A user must click "Publish" to make a collection viewable by others.
- Collections can be used for a variety of purposes. For example, a collection could be shown as a model in a training session; participants could be asked to copy it and make a modification, then rename the collection under their own name. This adaptation does not alter the original, and the metadata indicates that it is an adaptation.
- A user dashboard allows teachers to share collections and learning activities with individual students and groups of students, manage class rosters and assignments, and monitor progress.

Moving into the Future

Smithsonian Learning Lab is always evolving, becoming an increasingly rich, diverse, and valuable toolkit for immersive digital learning. This evolution is guided by teacher and student feedback, research and evaluation, and website use patterns.

- Some collections created by both educators and Smithsonian staff build bridges between the museum content and classroom needs.

For example, educators from the Smithsonian and the National Endowment for the Humanities created special resources for "Taking a Stand in History," the theme of National History Day 2017. As students use those collections in their projects, the Smithsonian will study what they found useful.
- Some collections are focused on instructional practice that encourages deeper thinking, such as several based on Harvard Project Zero's visible thinking routines. "Key Moments in World War II," for example, uses the "What Makes You Say That" routine to a photograph of the Japanese surrender. *http://s.si.edu/keymomentswwii.* Or, "Mary (Cassatt) and Katy (Perry): See, Think Wonder and Compare." *http://s.si.edu/maryandkate.*
- The behavior and needs of specific audiences are tracked and studied by the Smithsonian Center for Learning and Digital Access. For example, since a Smithsonian collection can be embedded on other websites, examples of use may be studied. A library may embed a cultural heritage collection made by the Smithsonian on its own website, using its content for community outreach or educational purposes. Ongoing research and evaluation provide information ranging from the straightforward (responses to a survey) to the complex (observations of use by both educators and students within their classrooms). This research informs the creation of new collections by Learning Lab staff.
- By analyzing the terms most often used for searches, the Smithsonian identifies needs and creates new collections and teacher support to address them. For example, when world history teachers found few resources on the origins of writing, the Center collaborated with experts to create a collection about it ("oracle-bone script," the earliest known form of systematic Chinese writing, in the Freer and Sackler Galleries, the Smithsonian's museums of Asian art). They then hosted a Google hangout session led by a curator to provide more explanation. This session archive with the digital images and metadata are all accessible via the Lab.

In all of these ways the Smithsonian brings the knowledge and experience of educators into its development process.

Approach:

Guided exploration of the biology concept of adaptation

How the Learning Lab was used:

- Teacher created a focused collection of images
- Teacher shared information about the images in the collection, referring to provided metadata
- Students analyzed images in the collection

Connection to deep, meaningful learning:

Students were introduced to a broad science principle—that evolutionary adaptations can be discerned in the features of an animal. They then applied their knowledge by making predictions of what sort of adaptations an animal would need. A follow-up hands-on activity deepens their understanding of adaptation.

First grade teacher Jon Berg, of the Inspired Teaching Public Charter School in Washington, D.C., wanted to help his students understand how adaptations contribute to the success of animal species. Images of animal beaks and tails from the Smithsonian collections served as perfect illustrations.

He began the activity with read-aloud texts, followed by class discussions. Among the books were *Who Has These Feet?* and *Who Has This Tail?* by Laura Hulbert, which look at animal adaptations in a fun way. Berg then led a class activity in which he shared the images he had collected in the Learning Lab. He read the captions aloud and asked students to recall what they had learned previously. The students compared and contrasted adaptations, and discussed why they vary among species.

Berg explained: "My collections included various types of images that featured the target species, including photographs, stamps, and drawings. I felt like the collection of Smithsonian images I created helped show students that they could find images connected to concepts they've studied from a variety of sources and in a variety of media—not just in photographs. I also like that the images are vetted by experts from the Smithsonian rather than from unknown or dubious sources on the Internet."

Berg followed up with a variety of activities designed to help extend student learning. For example, he read aloud to the class the book *Beaks!*, by Sneed B. Collard III, which introduces the many basic types of bird beaks and their functions. He asked students to make predictions and "text-to-world connections." According to Berg, this kind of conversation and feedback loop allows students to think about the topic more deeply. The students discover answers to their own questions and then "develop more targeted questions based on newly acquired information." Students also engaged in a hands-on activity in which they experimented with using tools to collect different types of food that birds eat, and were encouraged to explore Berg's online collection of images with their families at home.

This study of animal adaptations helped the children better understand that living things possess different mechanisms to defend and feed themselves. In the process, the students developed a deeper understanding of survival, heredity, and evolution.

PORTRAITURE AND PERSONAL IDENTITY (GRADE 1 INTERDISCIPLINARY PROJECT)

Approach:

Project-based learning

How the Learning Lab was used:

- Teacher modified an existing Smithsonian collection to meet her specific instructional needs
- Students analyzed images in the collection

Connection to deep, meaningful learning:

Students analyzed examples related to concepts of portraiture, applying their understanding by developing descriptions and sorting portraits into self-created categories. This experience helped the students understand both key elements of portraiture and the range of possible formats, styles, and approaches to portraiture. Based on the understanding they had developed, they created self-portraits and family portraits, demonstrating transfer of knowledge. At the same time, this project gave students the opportunity to explore, expand, and express a concept of self.

A key goal of early education is to help students develop such self-concept—to figure out who they are as individuals and within a community. To help meet this goal, 2016 State Teacher of the Year Susan Koch of Union Elementary School in Montpelier, Vermont, developed an interdisciplinary unit on portraiture that used resources from the Learning Lab. Her work was inspired by a teacher workshop at the Smithsonian.

During the previous school year, Koch's kindergarten students had completed a unit titled "All About Me?" in which they studied similarities and differences among themselves, including colors of eyes, skin, and hair and their facial structure. Building on this foundation, Koch had these same students—now in first grade—complete reading activities about identity. Then she introduced them to the art of portraiture through a Smithsonian online collection of portraits that she had adapted to meet her needs.

The collection included portraits in a variety of formats, even cartoons. Displaying the images on an interactive whiteboard, Koch led a class discussion in which students shared observations, made connections, and developed descriptions. The children also worked in small groups with printouts of the portraits. Said Koch: "Some students compared the portraits and began sorting them into groups they determined themselves."

Students created self-portraits, then after examining portraits of mothers and fathers, they created portraits of their own family members. Toward the end of the year, they compared their self-portraits with photographs Koch had taken of them throughout the school year—looking to see if anyone looked different over the 180 days they had been together.

According to Koch, the value of the Smithsonian resources was in the range of styles that were available, which showed the students that there were many possibilities. One student mentioned that she had never seen so many pictures in one place before.

Approach:

Guided exploration of social studies concepts related to culture, guided development of social studies skills related to information processing, and project-based learning

How the Learning Lab was used:

- Teacher created a focused collection of images
- Students analyzed images in the collection and recorded information about them from the provided metadata

Connection to deep, meaningful learning:

Students integrated information from their examination of pictures of masks—from a range of cultures across Africa—and their reading about the masks. In so doing, they had the opportunity to synthesize information about the design, significance, and uses of masks and to deepen their understanding of culture in general. They applied their understanding (a dimension of knowledge transfer) by creating their own masks and describing their personal significance.

Authentic digital resources can help bring life to student learning about concepts, and can also provide a springboard for students' own creative hands-on activities. This was demonstrated in an art-integrated project designed by Kelly Heilman, a social studies teacher at Pittsburgh Langley K-8 (PA), who created a collection of twelve images of African masks from the Smithsonian's National Museum of African Art to use as part of her sixth-grade unit on African geography and black history.

The collection included masks from Mali, Cameroon, Liberia, Sierra Leone, Guinea, Nigeria, and the Congo. Each mask was created using indigenous materials, including wood, iron, cloth, animal horns and skin, plant fibers, and bamboo, covered with natural pigments.

Working in small groups, students examined the mask images, read information about the masks, and filled out worksheets explaining what each mask looked like, what area or tribe it was from, what it was made of, and what it was used for. This activity addresses several Pennsylvania state social studies standards, including content-related standards (e.g., describing and locating places and regions as defined by physical and human standards; describing the human characteristics of places and regions using criteria of culture) and information-processing standards (e.g., integrating information presented in different media or formats to develop a coherent understanding of a topic or issue).

As a follow-up, students exercised their creativity by fashioning their own masks. Each student was given a half-shell masquerade mask and a variety of other materials. They were asked to describe how they created their mask and what their creations meant to them. In other words, they described personal connections to what they had learned.

Approach:

Guided exploration of historical concepts and concepts related to story structure (e.g., protagonist and settings); guided development of student skills in reading and interpreting literary texts; support for the student writing process

How the Learning Lab was used:

- Teacher created a focused collection of resources with ties to a specific period of history
- Students analyzed resources in the collection and their relationship to a work of historical fiction
- Students conducted their own searches and built their own collections related to specific vocabulary terms
- Teacher created a collection of resources that students used as inspiration for writing

Connection to deep, meaningful learning:

Students examined artifacts to deepen their understanding of a work of literature and the time period in which it is set, and extended their knowledge through further research. Additionally, they used their new knowledge to write their own narratives—another example of transfer to a creative context.

English teacher Kathy Powers, a National Board-certified teacher and the 2011 Arkansas Teacher of the Year from Carl Stuart Middle School in Little Rock, had explored a variety of ways that resources in the Smithsonian Learning Lab can help her students dig deeper in their understanding of stories and other texts—both those they read and those they create. In the process, she was able to develop resources to help meet the specific needs of her English language learner (ELL) students.

After her students read *Bud, Not Buddy*, a novel by Christopher Paul Curtis set in the 1930s, Powers had them review a Learning Lab collection she had created, which included a photograph of a "Hooverville," a Pullman Porter cap, a baseball used in the 1937 All-Star Game, and a clip of a jazz tune. Said Powers: "Students were excited to discover objects they 'knew' from references in the book. The Learning Lab fostered an almost personal connection between my students and the author as they researched the history behind the artifacts and then analyzed how the author wove that history into his fictional tale."

One of the greatest challenges for teachers of struggling readers is helping them understand the vocabulary they need to know in order to read authentic texts. Powers found ways to use Learning Lab resources to address that challenge. Before assigning a novel about the assassination of Abraham Lincoln (*Assassin*, by Anna Myers), she led a class discussion of key terms such as *emancipation* and *secession.* Students then went to the Learning Lab to create their own collections of artifacts representing the words. This led, said Powers, to a deeper understanding of the concepts, even for those whose native language was not English. One student who knew very little English used tools such as Google Translate to gain a basic understanding of a term, then searched for visual examples. For example, for *vile*, he filled his collection with images of battles, monsters, and even a picture of broccoli—sparking intense debate among class members about whether the term "vile" could apply to vegetables.

Powers also found a way to help students visualize story elements for their own writing using the Smithsonian resources. She created a collection that included a variety of portraits of people, images of animals, and landscapes, ranging from photographs to abstract paintings. She then challenged her students to choose items in the collection for the protagonists, antagonists, and settings in stories they were writing. They could then use the images as story illustrations. According to Powers, her students were fascinated by the variety of images. In one case, a student chose a rough sketch for a seventeenth-century work titled *Portrait of a Prelate.* Another student objected on the grounds that it looked too sketch-like to be a character. The result was a passionate discussion that ranged from genres of writing to the definition of *prelate.*

Approach:

Project-based learning

How the Learning Lab was used:

- Teachers provided guidance to students on conducting their own searches
- Students conducted their own searches and reviewed the resources they found, including the metadata
- Students built their own collections
- In other activities, teachers created focused collections of resources that students analyzed

Connection to deep, meaningful learning:

Students conducted searches for three historical resources (an image, a symbol, and a quote) and extended their knowledge about the resources through exploration of metadata and additional research. They applied their knowledge by creating a design and justifying their design on the basis of the research they had conducted. In other activities, students analyzed resources and used the new information to extend understanding of concepts they were being taught—an example of knowledge transfer.

Social studies teachers Jane Joyce and Scott Slater and instructional-technology specialist Shannon Martindale of Moon Middle School in Moon, Pennsylvania, wanted to help their eighth-grade students develop a deeper understanding of the Revolutionary War while addressing Pennsylvania Core Standards for reading and writing in history and social studies. They did this by developing a blended project in which students searched for primary sources on the Learning Lab and then organized the items into collections. The goal was for each student to commemorate the Revolutionary War by designing a coin. Each coin incorporated a chosen image, symbol, and quote.

According to the teachers, the Smithsonian resources are authentic, credible, and interesting—making the perfect pairing for this project. "It made their learning more real," stated Joyce. "My students were excited to see the actual artifacts in the Learning Lab and have the opportunity to create."

To help their students identify useful resources, the teachers developed a "cheat sheet" listing such search terms as "diplomats," "politicians," "places," "mottoes," and "symbols" related to the Revolutionary War. Students read background information from the Learning Lab on each of the resources they found. They extended their learning through independent research. Each student then created a Learning Lab collection and a PowerPoint presentation to accompany the coin design. The class voted on the best design. The teachers assisted with a laser printing of the winning coin so that the class would have a souvenir of the project.

Over the course of the year, the teachers developed other ways of using the Smithsonian Learning Lab to enhance their social studies classes. For example:

- Students analyzed a teacher-curated collection of images of George Washington, including paintings and sculpture. They analyzed how Washington was portrayed by others, compared to how he portrayed himself in writing.
- Students reviewed a storyboard of images depicting the Lewis and Clark expedition, determining obstacles the explorers overcame and their achievements on the journey.

Approach:

Project-based learning, guided development of skills related to analyzing sources

How the Learning Lab was used:

- Students conducted their own searches for images
- Students analyzed images
- Students annotated images using the hotspot feature

Connection to deep, meaningful learning:

Students analyzed examples of portraiture, conducted additional research, and used what they learned to extend and deepen their knowledge of specific historical events.

Tom Gray, a social studies teacher at Shaler Area Middle School in Glenshaw, Pennsylvania, brought to life for his eighth-graders the 1824 U.S. presidential contest between Andrew Jackson and John Quincy Adams by asking the students to work in groups as Jackson's "campaign manager." As part of their job, they had to select portraits from the Smithsonian Learning Lab that portrayed the right symbolism and message to get Jackson elected.

To set the stage, students learned background information about Andrew Jackson's loss to John Quincy Adams in 1824. Students searched the Learning Lab for portraits of Andrew Jackson, then analyzed the portraits—about 200 total.

"The Learning Lab offers an impressive wealth of resources. Images are digitized in the highest resolution possible, enabling students to explore historical content in great detail to make their learning come alive," according to Gray. "The kids were holding their iPads and you could see them twisting them around, as if they were actually holding the item, zooming in and out."

Working from a primary source analysis worksheet from the Library of Congress, each student group added at least five "hotspot" annotations, identifying elements of the image that represented Jackson as "as a leader and fighter for the common man" and explaining why they had selected that portrait. They also researched online to find out more about elements they found in the image in order to better understand issues of the day, symbols, landmarks, and more. As a culminating activity, students created their own political posters and presented their creations and research findings to the class.

"It's really amazing to see kids walk into a history class, and they can't wait to get there," Gray commented. "Students were engaged in the lesson and out of their seats working with their classmates, discussing and sharing the images and research they found. My at-risk students were some of the most engaged in the project and showed deep understanding of the content."

*LOCAL CONNECTIONS WITH THE CIVIL RIGHTS MOVEMENT
(HIGH SCHOOL AMERICAN GOVERNMENT EXPLORATION)*

Approach:

Guided exploration of the Civil Rights movement, guided development of skills related to analyzing sources

How the Learning Lab was used:

- Teacher created a collection of photographs with a local historical focus
- Teacher uploaded additional photographs from other sources to add to the collection
- Students analyzed photographs in the collection

Connection to deep, meaningful learning:

Students used prior knowledge about a historical topic, added to that knowledge through examination of primary source photographs, then "recontextualized" their knowledge with additional information about the local setting of those photographs—all deepening their understanding of the topic. In the process, students applied historical analysis skills to specific cases, and so achieved a skills transfer.

High school social studies teacher Kris Hupp of Cornell High School in Pittsburgh, Pennsylvania, used resources from the Smithsonian Learning Lab and uploaded resources from other sources to help the students in his American government college prep class to recognize events that had taken place in their own city as part of the Civil Rights Movement.

Hupp started by having his students write five sentences describing what they knew about the movement. This was followed by a class discussion in which students mentioned important figures, places, and events, such as Martin Luther King Jr., Rosa Parks, Malcolm X, Montgomery, sit-ins, and marches. However, none of them mentioned people or events in their hometown of Pittsburgh.

Next, Hupp created a Learning Lab collection featuring relevant photographs from the Pittsburgh region, such as people protesting swimming pool segregation and a woman reading *The Life and Times of Frederick Douglass* in a bookstore. Sources of the photographs included both the Learning Lab itself and photographs Hupp had located from other sources, including local university collections and newspaper archives, and had then uploaded into his Learning Lab collection.

Hupp challenged his students to do their best to identify the time period, location, and subject of the photos. The students used the Smithsonian's *"Reading" Portraiture Guide for Educators* to help guide them in their analyses.

In the follow-up discussion, only one student recognized the Pittsburgh setting for his assigned photograph, which had been taken in front of the recently demolished Civic Arena. Another student said that she had seen a similar arena in West Virginia. Another pointed out that a photograph of the protest seemed to have been taken some-where in the North, rather than the South, because the trees did not have leaves and people were wearing coats.

On learning that all of the photographs had been taken in the Pittsburgh area, many of the students were shocked that there had been so much discrimination in the area. "It was a really great opportunity for students to take time to analyze photographs that challenged their preconceived notions about our civil rights and our region," according to Hupp.

Research on effective instruction and on the development of authentic digital resource repositories suggests several ways that such repositories can help support deep, meaningful learning. For example, resource collections can serve as a medium for students to express that understanding as part of project-based learning. They can also provide materials for guided student examination, interpretation, and analysis to deepen understanding of specific concepts and principles. In so doing, students have the opportunity not only to develop their content knowledge, but also to develop critical thinking skills related to observing, analyzing, and interpreting sources of information.

Types of deeper learning activities

Types of deeper learning activities involving authentic digital resources from the Smithsonian Learning Lab described in this paper include:

- Student searches for authentic sources to illustrate an idea or concept
- Analysis of such authentic resources providing illustrations of an idea or concept—for example, finding similarities and differences among the resources
- Integration of knowledge gained from analysis of resources with prior learning and information from texts
- Creating content relevance by connecting and corroborating digital examples with real-world examples
- Development of analytical and discursive skills by selection, explanation, and defense of resources for specific purposes
- Student creation of artifacts modeled after authentic resources

While completing these activities, teachers and students used a variety of features in the Smithsonian Learning Lab. They conducted searches for relevant resources, created and shared collections of resources, edited existing collections, and annotated resources. In so doing, they demonstrated the broad potential both of the Smithsonian Learning Lab and of the resources to which it provides access, both to deepen student learning and to make it more meaningful.

Teaching strategies that contribute to success

Teaching strategies that contribute to successful Learning Lab activities include the following:

- Before digging into the digital resources, provide students with a conceptual foundation (e.g., through readings, direct instruction, or class discussion) to ensure that they have sufficient background knowledge.
- For primary students, introduce the resources in a teacher-guided class activity. Then begin small-group or individual activities.
- Use the resources in tandem with required texts, to provide context or elaboration for topics introduced in the readings.
- Provide guiding questions to support the process of analyzing sets of resources. Ask older students (middle school and above) to search for authentic digital resources in small groups or on their own. Provide appropriate teacher support and guidance (e.g., a list of search terms to try). This strategy might also be successful with upper elementary students.
- Motivate students by offering "knowledge creation" opportunities. These can include off-computer art projects and activities in which students create their own digital resources and resource collections.

REFERENCES

Abbott, F., & Cohen, D. (2015, April 9). *Using large digital collections in education: Meeting the needs of teachers and students*. Digital Public Library of America. Available May 9, 2016 from *http://dp.la/info/wp-content/uploads/2015/04/Using-Large-Collections-in-Education-DPLA-paper-4-9-15-2.pdf*.

Al Azri, R. H., & Al-Rashdi, M. H. (2014). The effect of using authentic materials in teaching. *International Journal of Scientific & Technology Research, 3*(10), 249-254.

American Association of School Librarians (AASL). (2007). *Standards for the 21st-century learner.* Chicago, IL: American Library Association. Available November 9, 2016 from *http://www.ala.org/aasl/standards/learning*.

Barron, B., & Darling-Hammond, L. (2008). How can we teach for meaningful learning? In L. Darling-Hammond, B. Barron, P. D. Pearson, A. H. Schoenfeld, E. K. Stage, T. D. Zimmerman, G. N. Cervetti, & J. L. Tilson, *Powerful learning: What we know about teaching for understanding* (pp. 11-70). San Francisco, CA: John Wiley & Sons.

Barton, K. C. (2001). A picture's worth: Analyzing historical photographs in the elementary grades. *Social Education, 65*(5), 278-283. Unpaginated version available October 31, 2016 from *http://www.socialstudies.org/system/files/publications/se/6505/650503.html*.

Berardo, S. A. (2006). The use of authentic materials in the teaching of reading. *The Reading Matrix, 6*(2), 60-69.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (1999). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Research Council.

Buffington, M. (2007). *How do teachers and students use museum websites?* Paper presented at the American Association of Museums Annual Meeting, Chicago, IL.

Condliffe, B., Visher, M. G., Bangser, M. R., Drohojowska, S., & Saco, L. (2016, May). *Project-based learning: A literature review (working paper)*. MDRC. Available August 22, 2016 from *https://s3-us-west-1.amazonaws.com/ler/MDRC+PBL+Literature+Review.pdf*.

Darling-Hammond, L. (2008). Introduction: Teaching and learning for understanding. In L. Darling-Hammond, B. Barron, P. D. Pearson, A. H. Schoenfeld, E. K. Stage, T. D. Zimmerman, G. N. Cervetti, & J. L. Tilson, *Powerful learning: What we know about teaching for understanding* (pp. 1-9). San Francisco, CA: John Wiley & Sons.

Finkelstein, N., Hanson, T., Huang, C.-W., Hirschman, B., & Huang, M. (2010, July). *Effects of problem based economics on high school economics instruction. Final report.* (NCEE 2010-4002). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education. Available August 22, 2016 from *http://ies.ed.gov/ncee/edlabs/regions/west/pdf/REL_20104012.pdf*.

Glatstein, J. (n.d.). *Formal visual analysis: The elements and principles of composition*. Available July 5, 2016 from *https://artsedge.kennedy-center.org/educators/how-to/from-theory-to-practice/formal-visual-analysis*.

Harris, C. J., Penuel, W. R., DeBarger, A. H., D'Angelo, C., & Gallagher, L. P. (2014, December.) *Curriculum materials make a difference for next generation science learning: Results from year 1 of a randomized control trial.* Menlo Park, CA: SRI International. Available August 22, 2016 from *https://www.sri.com/sites/default/files/publications/pbis-efficacy-study-y1-outcomes-report-2014_0.pdf*.

Harvard Graduate School of Education, Project Zero. *Artful thinking.* Available December 19, 2016 from *http://pzartfulthinking.org/?page_id=5*.

Holm, M. (2011, Fall). Project-based instruction: A review of the literature on effectiveness in prekindergarten through 12th grade classrooms. *Insight: Rivier Academic Journal, 7*(2). Available August 22, 2016 from *http://www.bie.org/object/document/project_based_learning_a_review_of_the_literature_on_effectiveness*.

Horwitz, R., & Intemann, C. (2007, April). *We are your audience.* Paper presented at Museums and the Web Conference 2007, San Francisco, CA. Available May 26, 2016 from *http://www.museumsandtheweb.com/mw2007/papers/horwitz/horwitz.html.*

International Society for Technology in Education (ISTE). (2008). *ISTE standards for teachers.* Available November 9, 2016 from *http://www.iste.org/standards/standards/standards-for-teachers.*

International Society for Technology in Education (ISTE). (2016). *ISTE standards for students.* Available November 9, 2016, from *https://www.iste.org/standards/standards/for-students-2016.*

Kelly, L., & Breault, K. (2007). Developing educational websites: Investigating internet use by students and teachers. In E. Nardi (ed.), *Thinking, evaluating, rethinking: Proceedings from ICOM-CECA 2006 Conference,* Universita' Tre, Rome.

Leftwich, M., & Bazley, M. (2009, April). *Pedagogy and design: Understanding teacher use of online museum resources.* Paper presented at Museums and the Web Conference 2007, Indianapolis, IN. Available May 26, 2016 from *http://www.museumsandtheweb.com/mw2009/papers/leftwich/leftwich.html.*

Mayer, R. E. (2002). Rote versus meaningful learning. *Theory into Practice, 41*(4), 226-232.

Milligan, D., & Wadman, M. (2015, April). *From physical to digital: Recent research into the discovery, analysis, and use of museums resources by classroom educators and students.* Paper presented at the Annual Conference of Museums and the Web, Chicago, IL. Available November 11, 2016, from *http://mw2015.museumsandtheweb.com/paper/from-physical-to-digital-recent-research-into-the-discovery-analysis-and-use-of-museums-resources-by-classroom-educators-and-students/.*

National Art Education Association. *National Core Arts Standards.* Availalble January 9, 2016 from http://nationalartsstandards.org.

National Council for the Social Studies (NCSS). (2013). *The college, career, and civic life (C3) framework for social studies state standards: Guidance for enhancing the rigor of K-12 civics, economics, geography, and history.* Silver Spring, MD: NCSS.

National Governors Association Center for Best Practices, Council of Chief State School Officers (2010). *Common core standards for English language arts & literacy in history/social studies, science, and technical subjects.* Washington, DC: Author.

National Portrait Gallery Education Department. (2014) *Reading portraiture guide for educators.* Available December 19, 2016 from *http://www.npg.si.edu/docs/reading.pdf.*

National Research Council (NRC). (2012a). *Education for life and work: Developing transferable knowledge and skills in the 21st century.* Committee on Defining Deeper Learning and 21st Century Skills, J. W. Pellegrino & M. L. Hilton (Eds.). Board on Testing and Assessment and Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

National Research Council (NRC). (2012b). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: The National Academies Press.

Newmann, F. M., Secada, W. G., & Wehlage, G. G. (1995). *A guide to authentic instruction and assessment: Vision, standards, and scoring.* Madison, WI: Center for Education Research.

NGSS Lead States. (2013). *Next Generation Science Standards: For states, by states.* Washington, DC: The National Academies Press.

Smithsonian Center for Education and Museum Studies. (2012, October). *Digital learning resources project, vol. 1: Review of literature.* Available May 9, 2016 from *http://smithsonian-digital-learning.wikispaces.com/file/view/DLRP_Volume-I_Literature-Review.pdf/380888876/DLRP_Volume-I_Literature-Review.pdf.*

Smithsonian Institution. (2009). *Inspiring generations through knowledge and discovery: Strategic plan, Smithsonian Instutition Fiscal Years 2010-2015.* Author. Available November 15, 2016 from *https://www.si.edu/Content/Pdf/About/SI_Strategic_Plan_2010-2015.pdf.*

Tamo, D. (2009). The use of authentic materials in classrooms. *Linguistic and Communicative Performance Journal (LCPJ), 2*(1), 74-78.

Thomas, C. (2014). Meeting EFL learning halfway by using locally relevant authentic materials. *English Teaching Forum*, *52*(3), 14-23.

Widdowson, H. (1990): *Aspects of language teaching.* Oxford University Press.

Wiggins, G. (1989). A true test: Toward authentic and equitable forms of assessment. *Phi Delta Kappan, 70*, 703-713.