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ABSTRACT | Many arts-focused colleges and universities in the United States offer their undergraduate students coursework in science. To better understand the delivery of science education at this type of institution, this article surveys the science programs of forty-one arts-oriented schools. The findings suggest that most science programs are located in general education departments alongside other liberal arts disciplines, and at most of the schools students are required to complete at least one science course. The findings also suggest that the context of science education at arts-focused colleges may encourage innovation in pedagogy and curriculum development. This article highlights courses and assignments from Emerson College and other schools in which scientific topics are aligned with arts fields or framed to emphasize the societal relevance of science and its place in our daily lives.

KEYWORDS | civic engagement, curriculum, general education, liberal arts, pedagogy, science literacy, undergraduate

The U.S. higher education landscape features a range of institutions with particular foci, including many colleges and universities dedicated to training in the arts. However, despite this specialization, many arts-focused schools offer undergraduate coursework in a variety of other subjects, including science. Under these circumstances, science programs are likely to feature small numbers of faculty members, limited financial resources and scientific infrastructure, and difficulties in engaging students in multiple, sequenced science courses. Such conditions are challenging for instructors, but they may create opportunities that lead to curricular and pedagogical innovations in science education.

To better understand the delivery of science education at arts colleges, we explored the science programs of the thirty-eight U.S. undergraduate institutions with membership in the Association of Independent Colleges of Art and

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Design, along with three other arts-focused colleges: Berklee College of Music, Columbia College Chicago, and Emerson College. We surveyed the Web sites of these forty-one colleges in 2014, examining the structure of their science programs and the way they are situated in the larger institutional context and noting whether undergraduates are required to complete coursework in science. This survey provides useful insights into the design and administration of science programs at arts colleges, and our findings highlight lessons that other colleges and universities might learn from the science pedagogy and curricula of schools focused on arts education.

Results

The institutions included in this analysis are located across the United States and range in size from <100 to >9,600 (median = 776; mean = 1,386) undergraduate students (Table 1). Of the forty-one schools, twenty-three require students to complete at least one science course, eleven more require coursework in either science or mathematics, and seven have no science requirement. Of the twenty-three schools where a science course must be completed, five require students to take either two or three courses.

In nearly all cases, including some schools where science courses are offered but not required, science faculty and/or curricula are based in a general education–focused academic unit, such as Liberal Arts, Critical Studies, or Humanities and Sciences. Only Columbia College Chicago, the largest institution in our survey, has a stand-alone Science and Mathematics Department.

Table 1 | Characteristics of the Colleges and Universities Analyzed in This Study

School	*Location*	*Enrollment*[a]	*Curricular Location of Science*	*Number of Required Courses*
Art Academy of Cincinnati	Cincinnati, OH	187	Liberal Arts	1 science
Art Center College of Design	Pasadena, CA	1,434	Humanities and Sciences	2–3 science
Berklee College of Music	Boston, MA	4,286	Liberal Arts	1 science/ math

(*continued*)

Table 1 | Characteristics of the Colleges and Universities Analyzed in This Study (*continued*)

School	*Location*	*Enrollment*[a]	*Curricular Location of Science*	*Number of Required Courses*
California College of the Arts	San Francisco, CA	1,362	Critical Studies	1 science
California Institute of the Arts	Valencia, CA	933	Critical Studies	2 science/ math
Cleveland Institute of Art	Cleveland, OH	546	N/A	N/A
College for Creative Studies	Detroit, MI	1,109	Liberal Arts	1 science
Columbia College Chicago	Chicago, IL	9,671	Science and Mathematics	3 science/ math
Columbus College of Art and Design	Columbus, OH	1,268	Liberal Arts	N/A
Cooper Union	New York, NY	868	Humanities and Sciences	N/A
Corcoran College of Art and Design	Washington, DC	302	N/A	N/A
Cornish College of the Arts	Seattle, WA	776	Humanities and Sciences	1 science
Emerson College	Boston, MA	3,662	Liberal Arts	1 science
Kansas City Art Institute	Kansas City, MO	816	Liberal Arts	1 science
Laguna College of Art and Design	Laguna Beach, CA	436	Liberal Arts	1 science
Lesley University College of Art and Design	Cambridge, MA	477	Liberal Arts	1 science
Lyme Academy College of Fine Arts	Old Lyme, CT	68	Liberal Arts	1 science

School	Location	Enrollment[a]	Curricular Location of Science	Number of Required Courses
Maine College of Art	Portland, ME	360	Liberal Arts	2 science
Maryland Institute College of Art	Baltimore, MD	1,862	Humanistic Studies	1 science/ math
Massachusetts College of Art and Design	Boston, MA	1,800	Liberal Arts	1 science/ math
Memphis College of Art	Memphis, TN	330	Liberal Arts	1 science/ math
Milwaukee Institute of Art and Design	Milwaukee, WI	662	Liberal Studies	2 science
Minneapolis College of Art and Design	Minneapolis, MN	622	Liberal Arts	1 science
Montserrat College of Art	Beverly, MA	385	Liberal Arts	1 science
Moore College of Art and Design	Philadelphia, PA	473	Liberal Arts	N/A
New Hampshire Institute of Art	Manchester, NH	503	Liberal Arts	1 science
The New School Parsons School of Design	New York, NY	4,027	N/A	N/A
Oregon College of Art and Craft	Portland, OR	149	General Studies	2 science/ math
Otis College of Art and Design	Los Angeles, CA	1,093	Liberal Arts and Sciences	1 science
Pacific Northwest College of Art	Portland, OR	418	Liberal Arts	2 science
Pennsylvania Academy of the Fine Arts	Philadelphia, PA	206	Liberal Arts	2 science/ math

(*continued*)

Table 1 | Characteristics of the Colleges and Universities Analyzed in This Study (*continued*)

School	*Location*	*Enrollment*[a]	*Curricular Location of Science*	*Number of Required Courses*
Pennsylvania College of Art and Design	Lancaster, PA	237	Liberal Arts	1 science/ math
Pratt Institute	Brooklyn, NY	3,022	Liberal Arts and Sciences	2 science/ math
Rhode Island School of Design	Providence, RI	1,971	Liberal Arts	N/A
Ringling College of Art and Design	Sarasota, FL	1,341	Liberal Arts	1 science
San Francisco Art Institute	San Francisco, CA	440	Liberal Arts	1 science/ math
School of the Art Institute of Chicago	Chicago, IL	2,471	Liberal Arts	2–3 science
School of the Museum of Fine Arts	Boston, MA	569	N/A[b]	1 science
School of Visual Arts	New York, NY	3,481	Humanities and Sciences	1 science
University of the Arts	Philadelphia, PA	1,882	Liberal Arts	1 science
Watkins College of Art, Design, and Film	Nashville, TN	312	General Education	1 science

[a] Number of full-time undergraduates enrolled in fall 2012.

[b] Science courses available through partnerships with Tufts University and Northeastern University.

Discussion

Organizational Fit of Science at Arts-Focused Colleges

This analysis shows that a similar science education framework exists at most of the arts-focused colleges in our study. Science programs tend to be based in a unit with other general education disciplines, rather than existing as stand-alone

departments, and most of these colleges require science coursework as part of the general education curriculum. This suggests that science is valued as a component of this type of undergraduate education, but science programs are relatively small in terms of faculty numbers and resources, and thus they are embedded in larger, broader academic units. There are other ways to provide arts students with coursework in science as part of their undergraduate education, including partnerships with neighboring institutions. We encountered several examples of partnerships in our survey: Cleveland Institute of Art students take science courses at nearby Case Western Reserve University; students at the School of the Museum of Fine Arts are able to enroll in science courses at Tufts University and Northeastern University, all located in the Boston area; and the University of the Arts partners with the University of the Sciences, both located in Philadelphia.

Types and Examples of Science Courses at Arts-Focused Colleges

Various types of science courses are offered at arts-focused colleges, including traditional scientific disciplines such as biology, chemistry, and physics. But our analysis also revealed the frequent presence of two other categories of science course: those explicitly linked to the arts and those oriented toward civic engagement. Courses with an arts focus included Anatomy for the Artist at the Cleveland Institute of Art; Optics, Color, and Light at the College for Creative Studies; Seeing: Photography and Science at Lesley University College of Art and Design; Physics of Music at Massachusetts College of Art and Design; Geometry of Art and Nature at the School of the Art Institute of Chicago; and Biology in the Visual Arts at Watkins College of Art, Design, and Film. These courses integrate scientific topics and approaches with various artistic fields, thus making direct connections between science and the students' primary studies. On the other hand, civic engagement courses included Science and Sustainability at the Art Center College of Design; Biology of AIDS: Life of a Virus at Columbia College Chicago; Plants and People at Columbus College of Art and Design; Personal Genetics and Identity and Science and Politics of Water at Emerson College; Natural Catastrophes at Pratt Institute; and Food, Fuel, Future at Ringling College of Art and Design. These and other courses focused on environmental issues and human health topics highlight the societal importance of science and its relevance to our daily lives.

Student Learning Objectives in Arts College Science Courses

While some student learning objectives may be incidental to science concepts, such as the goal of understanding "the perceptual problems of drawing from the live model" in the Anatomy for the Artist course at the Cleveland

Institute of Art, science-related student learning objectives may be no different at arts-focused colleges than at more traditional institutions. For example, in our science courses at Emerson College, students "explore existing knowledge in particular natural or physical domains, learn that science is an approach to acquiring more reliable knowledge of the natural world, and identify how science pertains to students' own lives" (http://www.emerson.edu/liberal-arts-interdisciplinary-studies/liberal-arts-curriculum/perspectives). The specific learning objectives that frame our courses are (1) identify and explain the key information that forms the content of this course ("knowledge acquisition"), (2) critically evaluate scientific information and apply the scientific method ("scientific literacy"), and (3) accurately communicate scientific information in a way that reflects understanding of the impact and relevance of science in our daily lives ("science communication").

The first two learning objectives, knowledge acquisition and scientific literacy, would be common to any science course (e.g., Nelson Laird, Niskode-Dossett, & Kuh, 2009), while our science communication learning objective connects the science curriculum to the mission of Emerson College to prepare students to innovate and lead in communication and the arts. In combination, not only do students become grounded in the content of a scientific discipline, or multiple disciplines in courses such as Climate Change or Energy and Sustainability, and more capable of critically evaluating scientific information, but these three learning objectives create a framework with great potential for pedagogical innovation. At Emerson College we have realized this potential using a number of assignments in which students learn about scientific process and content through arts-oriented projects.

Innovative, Arts-Oriented Pedagogy

Zines are eight-page mini magazines folded from a single 8.5-×-11-inch piece of paper that provide a design challenge to concisely communicate a sharable idea with visuals and text. Andy Yang (2010), a faculty member at the School of the Art Institute of Chicago, developed the use of zines in his science courses as a medium and mechanism for sharing the excitement of scientific ideas with broader audiences. While aiming to preserve the empowering way this assignment democratizes scientific content and encourages participatory scientific literacy, at Emerson College we have modified the zine assignment to additionally serve student learning of scientific process. For example, in Personal Genetics and Identity, students create gene zines that explain and evaluate a genetic test available for a human trait in the direct-to-consumer genetic testing market. Students are asked to reference and weigh the body of research upon which the test is based and draw informed conclusions about the validity and utility

of the genetic information. Similarly, in a seminar on evolution and human history, we use the zine assignment to communicate a recent development in evolutionary biology, incorporating a news story and a peer-reviewed research paper as sources. Students aim to articulate the scientific finding, digest and explain "how we know," and assess both the knowledge from the peer-reviewed literature and the public form it takes.

Many of our science courses at Emerson College feature creative final projects that offer an opportunity for our arts-focused students to effectively communicate scientific material in a way that takes advantage of their interests and talents. Using a medium of their choosing, students communicate a concept encountered during the course in a way that is informative and accurate as well as creative and engaging. Students design, animate, illustrate, write, and perform in a manner that showcases the value and positioning of general education courses in relationship to degree-granting areas of study. These projects are frequently mentioned in student responses to course surveys that ask for identification of the most beneficial aspect of the course, and students often report satisfaction with the challenge of framing their understanding within the knowledge domain of their primary focus and using scientific content in a way that is relevant to their interests.

In some courses, we have developed this creative final project assignment to incorporate scientific literacy skills and to engage with public campaigns and civic activities. For example, in our Energy and Sustainability course students work in teams to reduce the college's energy or material footprint first by researching an issue, broadly in the peer-reviewed science literature as well as more specifically to the college through local sources (e.g., interviews, the college Web site, and/or student-run news sources), and then by identifying relevant stakeholders and collaborating with them to develop multimedia information campaigns to change the behaviors necessary for reducing our footprint. In another example, we tied student work in DNA and Society to the Ask for Evidence campaign (http://askforevidence.org). Ask for Evidence is a public campaign that helps people look for the evidence behind news stories, marketing claims, and policies. Students identify topics of interest, such as the use of antibacterial products or links between diet and cancer, and route claims to the published data upon which they are based, asking claim-makers for information that is unavailable to them and evaluating the status of the evidence that they find. Students ultimately publicize their participation and describe their process on social media, communicate their work in the form of a blog-style "case summary," and then translate their informed conclusions about a claim into a creative project in the medium of their choosing. Students have written and performed songs about red wine and cancer, produced screenplays and podcasts about coffee consumption, launched countermarketing

campaigns against antibacterial teddy bears, and created parody infomercials about unsubstantiated product claims. This project engages students in the science-relevant claims that exist all around them, empowers them as public citizens to seek evidence-based arguments, and hones their skills in the critical evaluation of scientific information.

At Emerson College we have also developed upper-level "Science in Translation" courses where the pedagogical thrust of the whole course is designed for students to apply scientific content to their disciplinary arts and communication practices or to a civic or policy issue. As an example, we have developed a Science Communication Collaborative as the centerpiece of one of these courses, partnering students with local research scientists for a series of exchanges and mutual communication training opportunities. Through this collaboration, students experience guided exploration of a specific area of scientific research and encounter the need for effective science communication. Students observe the scientists as they work and communicate and build a relationship through interviews, discussions, and workshops in improv and science visualization. Ultimately students communicate their partner scientist's work in a variety of formats, including a press release, popular science writing, and a final short film or animation project. These final video pieces are exemplary of how students can apply their creative talents to scientific content and serve as high-quality deliverables that the scientists often use in communication about their own work. Through this project, students gain firsthand insight into the ways scientists identify, approach, and answer research questions. Students have the opportunity to apply their communication skills and creative talents to the science they learn from primary sources, classroom discussion, and independent research. Importantly, through the mutual training at the center of this pedagogical strategy, these communication and arts students have a direct and lasting impact on how scientists approach their own communication to a lay audience.

Opportunity for a Science Minor

Given that most students enrolled in arts-focused colleges are required to take just one course in science, curriculum planners and instructors are afforded an unusual degree of flexibility in terms of course content. If a student will only experience a single science course as an undergraduate, then that course need not be delivered as if it were part of a rigid curricular sequence. Instead, the course can be focused less on specific content and more on critical thinking and the exploration of science in other contexts, such as the arts or civic engagement. Thus, arts-focused colleges might be

viewed as incubators for the types of innovative courses described above that explore multiple scientific fields from engaging perspectives. That said, in our experience teaching at Emerson College we have encountered many students with a genuine interest in science and a desire to take several science courses. In response, we have developed upper-level offerings with prerequisites, along with a science minor involving both introductory and upper-level courses (Table 2). This type of curricular structure is not common in the science programs at arts-focused colleges, although there are some exceptions. For example, the California Institute of the Arts features a minor in critical studies in the area of science and math, Columbia College Chicago offers minors in biology and environmental studies, the Milwaukee Institute of Art and Design has a minor in natural sciences, and students at the Rhode Island School of Design can graduate with a concentration in environmental studies or scientific inquiry.

Table 2 | Framework and Courses of the Emerson College Science Curriculum

Level	*Human Biology and Health Courses*	*Environmental Science Courses*[a]
Introductory	SC210 Human Health and Disease	SC220 Energy and Sustainability
	SC211 Food and Nutrition	SC221 Meteorology
	SC212 Evolution and Human Nature	SC222 Earth Science: Natural Disasters
	SC213 The Brain and Behavior	SC223 Climate Change
	SC214 Plagues and Pandemics	SC224 Ecology and Conservation
	SC215 Personal Genetics and Identity	SC225 Science and Politics of Water
	SC216 DNA and Society	SC226 Plants and People
Upper	SC310 Science in Translation: Health and Genetics	SC320 Science in Translation: Environmental Science
	SC312 Visual and Spatial Perception	SC321 Environments, Ecosystems, and Cultures of the Past

Note: Students can receive a science minor by completing four of these courses, including one from the "Human Biology and Health" cluster, one from the "Environmental Science" cluster, and one upper-level course.

[a] The courses in this cluster also contribute to an interdisciplinary minor in environmental studies.

Conclusions

In this survey of undergraduate science education at arts-oriented colleges we found that (1) most of the forty-one schools included in the analysis require coursework in science, (2) science programs are typically located in general education–focused departments with other liberal arts disciplines, and (3) science offerings include innovative courses in which scientific topics are aligned with arts fields or framed to emphasize the societal relevance of science and its place in our daily lives. This analysis helps us better understand how science fits into the broader landscape at arts-oriented schools, and it also raises interesting questions about the specific goals and delivery of science education at these institutions: Are the types of learning objectives that we have developed for science courses at Emerson College utilized at other arts colleges? How do courses meet those objectives, and how is student learning assessed? Where are these approaches uniquely dependent upon and/or applicable to the arts-focused environment, and where might these curricular innovations intersect with and support science education more broadly? What are the student-to-faculty ratios in these science programs, what scientific specializations are typical among the faculty, and how much do these colleges rely on part-time science instructors? What are the goals and structures of science minors, and does minoring in science enhance art students' educational experience and/or professional opportunities? Future investigation of these questions would serve as a logical and meaningful extension of our initial analyses.

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NOTE

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