

ACS Reform of Introductory Science courses for Non-Majors Course Mini-grants
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Codifying Materials for the Presentation of Scientific Investigations into 17th Century Dutch Art

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Summary

The purpose of this proposal is to take an existing course, "Science in Art," which deals with the technical examination of 17th century Dutch paintings, and generate from the existing materials (over 800 Powerpoint slides, over 600 images, over 100 references) a CD-ROM to disseminate within Washington and Lee University, as well as other institutions. The course serves as a powerful, *highly* interdisciplinary synthesis of physics, chemistry, biology, neuroscience, economics, religion, politics, and history. The principal task is to take the existing materials and: (1) generate new non-copyrighted versions of existing copyrighted diagrams, (2) obtain copyright permissions on images that are essential to the project, (3) create hyperlinks to images for which copyright permissions are unavailable or prohibitively expensive. The course has been taught in 1999, 2003, and once as an independent research course for one student in 2002. The author of the proposal has published five papers in the *Journal of Chemical Education* in the past five years dealing with laboratory development for courses ranging from general chemistry through advanced inorganic synthesis and has developed those materials through NSF CCLI and MRI programs in nuclear magnetic resonance spectroscopic methods and through two W&L Class of '65 Excellence in Teaching grants.

Project Description

Goals and Objectives

I have taught a course entitled "Science in Art" twice during compressed six-week spring terms at Washington and Lee University in 1999 and 2003. The purpose of the course is two-fold: (1) forever change the way non-science majors and science majors look at art and (2) change the way these students think about science. The purpose of this proposal is also two-fold: (1) enable the course materials to be prepared in such a way that the course may be offered at W&L every other year during the spring term in an even more in-depth format and (2) prepare these course materials so that they may be employed at other institutions under a variety of conditions.

Background, Significance, Prior Activities Related to Proposal

Over the past decade, art and art conservation have been recognized as a means of providing scientific training to non-science majors. For example, the NSF has funded work in this area by Prof. Michael Henchman (Brandeis) and Prof. Patricia Hill (Millersville). (see, for example, Chronicle of Higher Education April 25, 2003) Faculty

such as Prof. Richard Hark (Juniata) and Prof. Ruth Beeston (Davidson) have developed courses in this area.

I slowly started developing my own course in 1994, my second year at W&L. The course is based on a passionate interest I developed at the age of 15 in 17th century Dutch Art. In addition to teaching the course in the spring term of 1999 and 2003, I have also taught the course in an independent study format to a W&L art history student who is currently pursuing graduate work in art history at the Institute of Fines Arts, New York University.

The course is extremely rigorous but presupposes no technical background beyond high school math and science. The course achieves depth by focusing almost exclusively on 17th century Netherlandish painting. By limiting the course to this time period and by not discussing sculpture, fresco, etc., we can analyze a more limited set of art materials and methods, and thoroughly link the scientific analysis of the works to the culture, history, economy, and scientific milieu of the “Dutch Golden Age.” What is gratifying is that many students from the course then apply what they have learned to their own personal study of other art periods and methods of their own personal interest after the course is over. I have received postcards from the worlds’ major art museums from many of my former students. In other words, although the scope of the course is limited to achieve depth, the depth of the course develops the students’ interest and confidence to the point where they broaden the scope of the course on their own.

Previous versions of the four-credit course have met eight hours per week for the six week term, and students have taken three out-of-class 90-120 minute tests, presented two 30 minute Powerpoint lectures, and written an eight-page final research paper. [In the spring of 2003, we covered over 830 Powerpoint slides in six weeks: 470 prepared by me, 360 prepared by the students.] The first week covers basic mathematics, significant figures, and dimensional analysis; fundamental aspects of nuclear reactions, particularly as they are applied to the pigment analysis technique of neutron activation autoradiography; basic optics of gratings, mirrors, lenses, and atmospheric optical phenomena (e.g., “brown-green-blue” perspective); and the wave-particle duality for the photon and electron (including the de Broglie equation, the Heisenberg uncertainty principle, and Einstein’s solution to the photoelectric effect). The second week is an accelerated course in chemical bonding and intermolecular forces, including the solutions to the Schrödinger equation that give the hydrogen-like atomic orbitals; electron configurations and periodic properties of the elements; Lewis dot pictures, covalent bonding, and ionic bonding; and valence bond theory and molecular orbital theory of bonding in organic molecules. The third week involves a heavy dose of analytical instrumental methods such as X-ray radiography, X-ray powder diffraction, scanning electron microscopy, Raman microscopy, infrared spectroscopy, infrared microscopy, infrared reflectography, gas chromatography, liquid chromatography, mass spectrometry, UV-vis spectroscopy, UV photography, and laser ablation methods. I also lecture about the chemical and biological decomposition of paintings and the factors that accelerate or decelerate those processes. The instrumental methods exam consists of students having a list of over a dozen instrumental methods on a 3x5 index card and using it as a cue to fill a bluebook from memory for 90-120 minutes on the techniques.

Thus, the first three weeks are a scientific boot camp; although the non-science majors in the course are typically uneasy about the amount and detail of the material, they

can be coaxed, prodded, cajoled, and conned into learning it at a level of sophistication that initially surprises them, and then becomes a source of pride. The course also enables the science majors to take some of their non-science colleagues under their wing, which has significant benefits. The science majors are fascinated by seeing a completely different context and combination of material from their earlier courses.

In the fourth week, the course establishes the context of 17th century Dutch art. Here the students take over the course and present lectures based on their own areas of expertise or interest as they apply to the historical context of 17th century Holland (especially the conflicts with Spain and England), the religious context of The Netherlands in the 17th century (the Spanish Inquisition, Calvinism, conflicts over Catholicism, the influx of Jews into The Netherlands), the economy of 17th century Holland (particularly the evolution of the Dutch shipping empire and an art market geared toward an emergent middle class, rather than one geared toward ecclesiastical patronage), Philip Steadman's analysis of Vermeer's interiors and evidence for Vermeer's use of the camera obscura, David Hockney's theories on the use of optical devices by old master painters, and finally I often have a pre-medical student lecture on the basics of the human visual system, or a neuroscience major lecture on perception and art.

In the fifth week of the course, I take over the class again and present a few hours of lectures on the major areas of 17th century Dutch painting (e.g., landscape, portrait, still life, religious, vanitas, history, genre, group portraits, maritime, etc.), as well as a quick synopsis of some of the major artists of the period (e.g., Rembrandt, Hals, Ruysdael, Cuyp, Hobbema, Vermeer, van Goyen, Saenredam, Steen, Dou, Leyster, etc.). I conclude the fifth week with a few hours of case studies that tie the course together, i.e., paintings that require scientific analysis, as well as a knowledge of the social and historical context. In the sixth week, the students take over the presentation of case studies. Student case study examples include Steen's "The Dancing Couple," Rembrandt's "Danae," Rembrandt's "The Night Watch," Frans Hals portraits in which family coats of arms were added to the paintings decades after Hals' death, Vermeer's "Girl with a Pearl Earring," etc. In the last week and a half of the course ethics and esthetics of art conservation become significant issues. We constantly ask the questions, "How much of this particular work of art is by the original artist? How much of the work has been treated by conservators over the centuries? What changes in appearance have transpired due to chemical decomposition and biological attack (e.g., mold, larvae, etc.) on the paintings? What changes in appearance have transpired due to prior bungling of conservation methods? What level of conservation treatment is appropriate for a given state of degradation?"

The number of physical, chemical, and instrumental principles covered in the course naturally leads students to ask questions not only about the applications to art, but also to important current issues. The discussion about nuclear decay reactions involved in neutron activation autoradiography typically gets students asking about atomic bombs, hydrogen bombs, and dirty bombs. The half-lives of radioisotopes inevitably lead to digressions into various geological dating methods that disagree with fundamentalist Christian assertions about the age of the earth. The probabilistic nature of quantum mechanics, coupled with its non-intuitive view of the microscopic universe, forces students to seriously consider their view of "reality." The destructive nature of many of

the analytical techniques discussed limits the quantity of samples and the location of the samples in the painting. This leads to a discussion on the statistical confidence in analysis, and the impact of limited sampling on that confidence. Good students inevitably ask questions about how that statistical sampling question applies to other areas of science; consequently, relevant climate and environmental sampling issues can be discussed. Thus, although the course does not delve into those issues purposefully, those issues arise naturally as a consequence of the material covered---the course generates valuable digressions.

Detailed Project Plan, Implementation, and Timetable

There are two goals of this proposal: (1) create a foundation for the course that will enable me to teach it every other year with materials that comply with copyright law (2) generate these materials in such a way that they may be shared with the science and humanities educational communities external to W&L. Currently, the several hundred Powerpoint slides I have prepared use several hundred images. Thus, a template for the course materials exists. [If you want to see a sample lecture from the course, visit <http://blackboard.wlu.edu:8080/?bbatt=Y> and login as username “goldenage” and password “1669” and look for “Science and Art” under “my courses”---that will take you to a Powerpoint presentation on X-rays in art analysis.] To make these materials available to a wider audience on a repeatable basis, three strategies must be pursued with these images (1) replace current images of diagrams with images which we generate, (2) replace images by hyperlinks to websites that legitimately have copyright, or (3) obtain copyright permissions on images. I have contacted our copyright expert in the W&L Law School Library, and I have contacted the copyright permissions person at Thomson Learning (a wing of the Thomson publishing conglomerate). After these conversations, it is obvious that a combination of all three strategies should be pursued. Therefore, the work this summer will involve: hiring a student to create diagrams and images based on those materials we have already in hand, partnering with Thomson Learning’s permissions service to obtain copyright permissions on images which cannot be redesigned, and replacing images with valid hyperlinks to legal sources of those images. Although this will involve significant effort, the materials are already organized and ready to be processed, based on previous work with the course. Thus, the objective by the end of the summer of 2004 will be to have generated the new images we need to replace copyrighted images and to have determined which copyright permissions may be obtained at what level of expense. By December of 2004, the objective will be to have obtained those copyright permissions essential to the project, and to have created the valid hyperlinks to images for which hyperlinks exist and for which copyright permission would be too expensive. In the spring of 2005 the course will be taught, and the results and voluminous accompanying support material will be submitted to the *Journal of Chemical Education* and disseminated through other suitable formats. I also anticipate submitting this effort for presentation at the August 2005 National American Chemical Society meeting, and presenting these results at meetings deemed fit by the Associated Colleges of the South.

Context of Course in the Curriculum:

The Chemistry Department at Washington and Lee University currently offers three non-science majors courses on a regular basis: “Disorder and Chaos”: a lab course

in nonlinear dynamics funded by the Keck Foundation, “Chemistry in the Marketplace”: a non-lab course in the science and economics of industrial processes, and “Modern Descriptive Chemistry”: a lab course in general chemistry for non-scientists. The W&L Art Department has sent majors to my Science in Art course, and it is my intention, by increasing the frequency with which the course is offered, to further enhance the participation of art majors in the course. In addition, I am currently exploring ways of taking students in the class to The Netherlands for the last two weeks of our spring term so that an international education component would be built into the course. I have had discussions with our International Education office on these matters, and I have a proposal pending with our Global Stewardship Committee.

Impact on Institution

The Science in Art course has served 10 students and 8 students in 1999 and 2003 respectively, in addition to the independent study student in 2002. It is my intention to build the course to serve 20-25 students on an alternate year basis. The course serves as a powerful, *highly* interdisciplinary synthesis of physics, chemistry, biology, neuroscience, economics, religion, politics, and history.

Evidence of Institutional Support

See attached letter from the Interim Dean of the College, Dr. Jeanine Stewart.

Evaluation, Dissemination, and Continued Support

Since the course has already been taught in 1999 and 2003, as well as in an independent study format in 2002, much of the work has been evaluated. Student responses to the course have been overwhelmingly positive, and I receive comments from students about the class for years after they have taken it, and many of these students do not pursue careers in science or art. The independent study student is currently pursuing graduate studies in art history at the Institute of Fines Arts, New York University. She wrote to me the following:

In every class I have taken words such as infrared reflectography or dendochronology are part of the basic vocabulary. Knowing the chemical composition of a pigment can determine a forgery; reflectography allows scholars to gain an insight to an artist’s working methods. Conservation techniques have added a new method for art historians to approach a work of art. My previous course work in chemistry and conservation techniques allows me to follow class discussions knowledgably and to apply that information to my own studies. With the constantly expanding scientific techniques applicable to the field of art, it is pertinent to have grounding in chemistry and even physics. My coursework at Washington and Lee University gives me the ability to think of art both theoretically and scientifically, two essential components for a well-rounded art historian.

My evaluation of the work in the future will significantly be measured by increasing the enrollment of the course and seeing how the course maintains student interest in larger numbers.

I have indicated above my intentions to disseminate the results both in the chemical educational literature and at educational meetings within the American Chemical Society and Associated Colleges of the South. My experience with this type of

work can be summarized as follows: I was the project director and the lead PI on NSF 9650033 [High-Field Multinuclear NMR in Undergraduate Education at Washington and Lee University; ILI-IP, 6/1/96-5/30/98, with colleagues Dr. Marcia France, Dr. Steve Desjardins, and Dr. Lisa Alty. The grant resulted in the purchase of the W&L Chemistry Department's JEOL Eclipse+ 400 MHz NMR in 1996. Seven publications were a direct result of the ability to perform high-field NMR experiments in our department,¹⁻⁷ and one additional publication has been submitted.⁸ Out of these, five have included undergraduate students as co-authors.^{1,3-5,7} Because one of the primary functions of this instrument was for educational purposes, six publications have been published in or submitted to the *Journal of Chemical Education*.^{1,2,5-8} The other two publications were research oriented.^{3,4} Our undergraduate chemistry students have also presented their research results using the NMR at national and regional meetings, fourteen presentations altogether (six involving Uffelman).⁹⁻²² Four student honors theses were generated. In 2003, Uffelman, France, Desjardins, and Alty were co-PIs on NSF 0319528 [Multinuclear Gradient Inverse Probe, Amplifier, and Overnight Low Temperature Dewar for High-Field NMR Spectroscopy in the Chemistry Department at Washington and Lee University [MRI 8/1/03-7/31/06, \$ 70,830.00; Project Director---Uffelman], which allowed W&L to upgrade its NMR for running pulsed-field gradient experiments, as well as low temperature kinetics and dynamics studies.

Once the new materials for the Science in Art course have been prepared, there will be minimal need for further financial support.

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