

Interdisciplinary Opportunities Mini-Grants
Proposal Cover Sheet

Project Title: Teaching Scientific Reasoning to Undergraduates Across Disciplines

Institution: Millsaps College

Faculty/Staff Name: Patrick D. Hopkins

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Student(s) Name(s): Year Classification: N/A

Phone: E-mail:

Amount requested: \$6500

Please check the appropriate boxes: curricular proposal co-curricular proposal

planning & implementation planning only

Date grant submitted: Feb 15 2007

Proposed grant period: July 2007-May 2008

Type of project: creating new interdisciplinary course/course modules

Signature of faculty/staff submitting

proposal _____ Date Feb 15 2007

Signature of student submitting

proposal _____ Date _____

Patrick D. Hopkins, Chair of Phil Dept

Richard Smith, Dean

Name of appropriate dept./div. chair
Or chief student affairs officer

Name of Chief Academic Officer:





Signature of above chair or officer

Signature of Chief Academic Officer

Date Feb 15 2007

Date Feb 15 2007

Evidence of institutional support is required for each curricular mini-grant proposal in the form of a letter of support from the proposal author's Department/Division Chair. For co-curricular proposals institutional support is required in the form of a letter of support from the faculty/staff mentor/sponsor and a letter from the chief student affairs officer. All proposals must be signed by the chief academic office.

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By _____

Date sent to review Committee _____

Action _____ Notification sent _____

TEACHING SCIENTIFIC REASONING TO UNDERGRADUATES ACROSS DISCIPLINES

(ACS Interdisciplinary Opportunities Mini-Grants Application)

2. SUMMARY:

- Issue: We are seeking the most effective means to teach scientific reasoning and literacy in scientific methodology to a variety of undergraduates drawn from both science and the humanities. While we currently offer a great deal of applied and theoretical science courses, we have found through teaching and conversations with faculty that humanities students typically view science as a difficult hurdle over which they must jump and which they would prefer to criticize as being severely limited in its approach to answering important questions of human origin, behavior, and nature. On the other hand, we have found that science students typically learn how to perform certain tasks in the laboratory and learn a great deal of factual information but often do not learn much about the nature and structure of scientific methodology, reasoning, or epistemology. Our experience then, is that humanist undergraduates learn very little of how science practically works and advances while science students learn very little of how scientific methodology is organized and defended. These education experiences handicap both types of students. Humanities students are ignorant about scientific practice and techniques while science students are ignorant about scientific methodology and creativity.

- Goals: Our goal therefore is to improve on this situation by trying a systematic method of teaching scientific epistemology, methodology, and practice. The point is to defragment science education and bring it into holistic view. Science students need to know about the philosophical justification of empiricist epistemology so that they can distinguish what can and what cannot be approached and studied in scientific methodology, while humanities students need to know not only this but also how the actual practices, questions, and creative planning of scientific research begin, study, and end. To this end we wish to create a holistic and coherent new course which would begin with education in epistemology and empiricism, move toward an explanation of how the hypothetico-deductive method works in generating information (its strengths and limits), look at famous and groundbreaking experiments, select a few interesting and tricky empirical questions that could be approached through the scientific method, and generate through discussion and criticism a rational and coherent experiment which could get at those questions. The goal would be to educate students not only in the background epistemological and methodological problems of science but to culminate in designing an experiment that would use the intellectual critical skills they have learned to focus clearly on producing relevant data.
- Description: We will run a pilot program consisting of 2 faculty from 2 different disciplines, biology and philosophy. Together we will create a consistent, systematic course in scientific epistemology and methodology, co-taught and using a jointly produced syllabus with specific shared goals and a shared

vocabulary. The course will be targeted to junior and senior science and humanities majors and will teach the epistemological background of empiricism, the grounding of empirical methods in science, critical examples of famous experiments, and would result in a module in experimental design attempting to address specific and complex empirical questions.

- Outcomes: We intend to produce an effective and systematic course that trains students in the epistemology, methodology, and creative practice of science experimentation.

3. PROJECT DESCRIPTION

- Background: As a liberal arts institution, Millsaps College states that one of our primary tasks is to teach critical thinking and scientific reasoning. While we do offer many science courses, these classes typically teach students factual information and practical laboratory techniques but only teach the bare basics of how science actually works as a knowledge producing practice. Students typically do not learn about the epistemological background and foundations of empiricism nor do they learn about the issues of how experiments are designed in the first place with an eye toward isolating relevant observational events and determining how to interpret those events. In our recent pilot program in critical thinking for freshman (for which we were awarded an ACS minigrant and are currently analyzing the data we collected) we found we actually did a better job in explaining the intellectual background and foundations of empirical science when teaching a module on inductive reasoning. The philosopher involved in that pilot

program was fortunate to learn from the scientists in the program how better to judge the value of specific experiments and the scientists were fortunate to learn from the philosopher how better to explain the epistemological grounding and limits of empirical science (including the distinction between confirmation and proof, theories and hypotheses, the limits of finite empirical investigation, and the use of operational definitions). Out of that experience, we developed a general idea for incorporating more philosophy of science into courses dealing with scientific methodology and eventually came up with the idea of teaching a course, or at least modules of a course on the epistemology of science, the methods of science, experiment construction, and data interpretation.

- Goals: We want now to develop through planning and experience a course and a set of smaller course modules that can be used in our introductory science classes that better combine the intellectual foundations of empirical science with methodology and experiment construction. We want to teach as many students as we can get (whether science majors or non-science majors) that science is born of the specific epistemological position of empiricism, that science can confirm hypotheses but not prove inductive claims, that the creative and difficult part of science is to design experiments that isolate observable events in a way that leads to the most rational interpretation of those observations, and to give students experience in generating experimental designs in order to answer questions. Ultimately our goal is to achieve a broader and better understanding of science for our students, one that coherently addresses the foundations of

scientific reasoning and which trains students in how to assess and generate experimental designs.

- Plan: Two of the faculty who worked on the Critical Thinking initiative (Patrick D. Hopkins—Philosophy and Sarah Lea McGuire—Biology) hope to accomplish two things. We want to teach a half-course in the spring of next year that will be open to any student but which will likely be advertised primarily to science seniors and humanities seniors. This course will be organized into four parts. First, we plan to teach some epistemology to students and explain the origins and debates surrounding empiricism and from this beginning explain how science deals with observations, how observational evidence limits us to the scope of inductive reasoning, how science can therefore confirm observational claims but cannot conclusively prove claims, how science is essentially a philosophically pragmatic undertaking, how scientific theories are judged according to pragmatic principles (simplicity, fruitfulness, parsimony, explanatory power, predictive power, elegance, etc.), why and how science requires good experimental design, and how to assess good experimental design. Second, we want to examine famous and not so famous examples of important experiments to show how innovative and solid experimental design was at the basis of important discoveries (this is part of what we need to research but would likely include Semmelweis' experiments on childbed fever, Einstein's design of the bending light during an eclipse study, and the Michelson-Morley ether detection studies). Third we want to look at contemporary studies—some of which have gathered media attention—and learn how to assess the experimental design of

those studies with an eye to judging what can and what cannot be justifiably interpreted from the data. Fourth, we want to ask some questions and have students collectively (in small groups) design studies geared toward answering those questions (experimentally complex tasks such as testing whether animals have a sense of self). In many cases these experiments will not be able to be performed (because of lack of equipment and time) but the point will be to learn how to think through questions to see how they can be empirically addressed and to design experiments around them.

The second thing we plan to do in this program as a result of developing this course is to develop shorter modules of the course which can be incorporated into other classes, particularly our year-long interdisciplinary non-majors science course and also humanities courses including history and philosophy of science. Our goal is to produce “traveling” and teachable short course modules which will be able to better expose all our students in a variety of courses to scientific reasoning, through fun and creative exercises and interesting information on the history of epistemology and science. Our ultimate plan is to have these traveling and teachable modules available for all students to come across somewhere in their education (likely required basic science courses) so that we are able to truly teach the basics of scientific reasoning (and not simply facts about specific sciences) across our curriculum.

- Prior activities: Both faculty members involved in this proposal have recently taught in a pilot program (funded by and ACS minigrant) that focused on teaching

critical thinking to freshmen. A major part of that course focused on inductive reasoning and included a great deal of information and training on how to understand and assess scientific studies and statistical claims. As part of that program, Hopkins developed a lecture briefly explaining empiricism, scientific methodology, and the virtues of good scientific theories. McGuire and other scientists involved in that pilot program said that an expanded version of this lecture would be very useful for their science majors, who often learn what to do in the labs but don't understand why they are doing it in a particular way. It is from conversations about such things that we developed the idea to create and teach a half-semester course on scientific reasoning and methodology (half-semester because of overloads and time constraints, though we think a half-semester would accomplish what we need it to do and would likely attract more students). We still have a good deal to do in terms of creating the actual classes, but our vision for the course and related course modules is well underway to maturity.

- Timetable: In the fall of 2006 we began discussing the content and need for such course. In the spring of 2007 we continued those discussions. If successful in obtaining an ACS mini-grant McGuire and Hopkins would spend several weeks in the summer of 2007 researching appropriate course materials and organizing the course. In the fall of 2007 we would advertise the course and then teach it in the spring of 2008. From the experience of teaching the course we would develop shorter modules on scientific reasoning and further refine our vision for the course. This is a pilot program and we'd like to do pre- and post- tests of

scientific reasoning ability. Though we haven't had time yet to decide on a test, Lawson's Classroom Test of Scientific Reasoning is a respected standardized test. In the latter part of the spring of 2008 and the early part of the summer we would like to work up a paper on our experiences and submit it to a journal in college pedagogy.

- Budget:
 - Faculty stipends: since faculty will have to train and prepare new classes extensively over the summer (thus avoiding some potential summer teaching opportunities), and will likely co-teach the half-semester course as an overload, we would like to request a stipend of \$2500 per faculty member (for a total of \$5000, less than teaching a summer course would be).
 - Educational meetings. We would like to sponsor a meeting for all interested faculty in the spring of 2008 to discuss our experiences in teaching this course and hopefully recruit teachers or at least opportunities to come speak to classes on scientific reasoning. In order to encourage attendance we would like to ask for \$500 to cover photocopy costs for shared materials and to pay for lunch.
 - Incentives for other faculty: In order to motivate other faculty to learn how to teach the scientific module reasoning in their courses, we would like to offer a small stipend of \$250 each for those who would add the module. Being moderate in our hopes for interesting other faculty, we would only ask for four such stipends, for an amount of \$1000.
 - In all, this would be a request for \$6500.
- Context: This is the creation of a new course and set of course modules which will be taught as a stand alone course at first but could easily develop into a

modification of courses we already have, including philosophy of science, biology senior seminar, and our non-science majors introductory science course.

- Anticipated Impact: We hope to have at least a moderate impact on students, training them in both the basics and some finer points of scientific reasoning, methodology, and experimental design. This will increase the scientific understanding of our students and improve the ability to assess scientific studies in our humanities majors and the ability to formulate scientific experiments in our science majors.
- Institutional support: We have the full support of our institution. Please see cover sheet. Dean's letter is being sent separately.

4. EVALUATION

- Evaluation and Assessment Process: We will use three measures to evaluate the success of our proposed course and modules. First, we will measure student's scientific reasoning skills before and after the course (probably Lawson's Classroom Test of Scientific Reasoning), hopefully being able to compare pilot and non-pilot course students. While we know a single course cannot accomplish everything, we are interested to find out whether it will have a measurable effect. Second, we will use our standard student course evaluations to see if students have a good sense of what the purpose of the class was and whether they felt they learned something useful. Third, we will collect and write up faculty experiences of this class, paying special attention to whether faculty

think this class deals adequately with the dissatisfaction some feel with our current approach.

- Dissemination of Results: Our team will offer a special presentation to the entire faculty on the results of our course and our study. We will share test score data, evaluation data, and offer our own assessments as teachers of whether the course succeeded or not.
- Institutional continued support: the course we are creating is not part of our core curriculum but if it is successful, it could be offered a one or more modules of senior capstone courses in the science and as part of philosophy courses in epistemology and philosophy of science.

5. LITERATURE CITED

- Lawson, A. E. 2000. Classroom Test of Scientific Reasoning (Multiple Choice Version) Based on Lawson, A. E. 1978. Development and validation of the classroom test of formal reasoning. *Journal of Research in Science Teaching*, 15, 11-24.

6. C.V. OF FACULTY (please see attached): Patrick D. Hopkins (Philosophy), Sarah Lea McGuire (Biology)

7. DISCLOSURE STATEMENT

- this applicant (Patrick D. Hopkins) has no other on-going grant activities or activities that will coincide with the submitted proposal. I have received a previous ACS minigrant but that research will be entirely completed by the time the award for this proposal would begin.