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Stockholm Study Abroad: Scientific Breakthroughs and Nobel Laureates

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ABSTRACT

Undergraduate study abroad experiences and immersive international programs serve as rich learning opportunities and substantive creative endeavors. This is particularly true for honors students. This paper describes an honors course that was developed around the idea of the scientific method, targeted at exploring scientific breakthroughs and Nobel laureates, and conducted at the site where the majority of Nobel Prizes are awarded: the Karolinska Institute in Stockholm, Sweden. For the "Stockholm Study Abroad" course at The Pennsylvania State University, honors students were asked to examine elements of the scientific method as the underlying framework of research studies, discuss traditional and nontraditional research techniques used in science, elaborate and/or clarify selected scientific breakthroughs, pinpoint where creativity exists within scientists' accomplishments of selected breakthroughs, develop questions for Karolinska Institute scientists who are searching for breakthroughs, and explore The Nobel Museum for details of previous Nobel Prize recipients' careers in science. In addition to the rich academic experiences in which the students participated, this article discusses some of the practical elements involved in the planning of this course, including assistance with arranging lecturers and lecture halls, field trips, lodging, and partial university funding for student expenses. Also discussed are selected logistical topics such as the importance of obtaining agreements from guest lecturers at least six to nine months in advance and facilitating student discussion with international peers and equivalent-level students.

STOCKHOLM STUDY ABROAD: SCIENTIFIC BREAKTHROUGHS & NOBEL LAUREATES

What does it mean to be an undergraduate honors scholar? What is the nature of honors scholarship? Evidence for answering these questions can be readily found in undergraduates' international honors experiences and honors studies abroad.

The Pennsylvania State University (Penn State) values diversity in all of its forms. International study represents an educational environment enriched by the diversity of individuals, groups, and cultures that come together in a spirit of learning. To build an appreciation of the importance of understanding, respecting, and expanding diversity, Penn State is committed to providing access to—and fostering students' participation in—international programs, including those designed specifically for honors students.

International study offers multiple opportunities for students to expand their thinking. In so doing, international study forces students to think differently and at a higher level of synthesis. International study inspires students to think above and beyond traditional course boundaries of learning. The nature of international honors experiences serves as a clear reflection of honors scholarship.

This paper describes the development of a course that focused on exploring scientific breakthroughs and Nobel laureates in Stockholm, Sweden. In conjunction with the notion of honors study, a conceptual model that incorporates the scientific method formed the foundation for this and the preceding semester-long course.

WHAT ACTUALLY IS MEANT BY HONORS STUDY?

At the undergraduate level, honors study consists of academic pursuits that are more penetrating and research-oriented than traditional undergraduate coursework. Pursuing honors study involves more than simply studying a subject in greater depth and/or breadth; it involves greater abstraction, a higher level of complexity and organization (Werner, 1957), and guidance by a mentor or series of mentors in the form of honors advisors or instructors.

Discovery, integration, application, and teaching are four functional areas included in the Boyer (1997) model of scholarship. All four areas interact dynamically and, in so doing, form an interdependent whole. Because much of the substantive content contained in these two courses on scientific breakthroughs was new to them, many honors students focused more heavily on the **discovery** and **integration** types of scholarship rather than the application and teaching types. Nonetheless, the experience afforded students a competitive edge in their research techniques, which prepared them for future endeavors such as completing their honors theses and conducting possible graduate-level research.

Discovery is investigative and refers to a search for new information. At the core of scholarship, discovery is what "contributes not only to the stock of human knowledge but also to the intellectual climate of a college or university" (Boyer, 1997, pp. 17-18). *Integration* is what happens when scholars assimilate isolated facts into perspective, "making connections across the disciplines, placing the specialties into a larger context, illuminating data in a revealing way"—work that attempts to "interpret, draw together, and bring new insights to bear on original research" (pp. 18-19). Integration draws connections and examines contexts often in an interdisciplinary and interpretive way. Boyer sees integration and cross-faculty scholarship as a growing trend in universities, a scenario in which disciplines are converging and the boundaries between fields overlap and become blurred. The scholarship of *application* involves both applying relevant information and contributing to human knowledge development. Finally, the scholarship of *teaching* is conceptualized not only as an endeavor that involves transmitting knowledge but also one that *transforms and extends* it.

In the first course, conducted at Penn State, students were involved collectively in **the application of scholarship** as a class when trying to figure out a cure for a specific type of cancer. Students worked as a group and gave an hour-long class presentation to other faculty and an oncologist about the most promising avenues of research in finding a cure. In that same course, students were involved in **the application of teaching** through a regular weekly sharing of insights they had uncovered in their readings. A different student collected insights from each class member every week and distributed them the following week so that every student had a copy of the entire set. The majority of the students found both of these activities worthwhile and helpful to their own individual projects because of the shared learning and discovery.

In directing honors students toward ways of incorporating interdisciplinary and international courses into their plans of study, The Schreyer Honors College at Penn State frequently emphasizes and employs the **integration** functional area discussed in the Boyer model of scholarship. The Schreyer Honors College is a university-wide honors college for academically superior students, typically reserved for the top five percent of academic achievers. The Honors College promotes academic excellence within a broad realm—in education, practice, leadership, and international study—as well as within social and civic responsibilities. It is designed to challenge, enrich, and broaden general education as well as to enhance preparation for graduate or professional study by fostering scholarship and research-intensive experiences. At Penn State, special opportunities are offered to explore areas of interest within numerous international environments. Accordingly, Penn State's honors program gives students opportunities to be directly involved in discovery and integration in global contexts.

INSIGHT AND CREATIVITY AS CONCEPTUAL FOUNDATIONS OF HONORS

A list of underlying teaching and learning assumptions was assembled as a first step in developing the two courses on "Scientific Breakthroughs and Nobel Laureates" (see Appendix). These assumptions aided the faculty member designing the courses in developing the course objectives, readings, and learning experiences for honors students. That faculty member spent nearly a year conducting a comprehensive literature review on scientific breakthroughs and Nobel laureates to be studied subsequently during the trip to the Karolinska Institute and the Nobel Forum in Stockholm. Keywords used in her literature search included: searching and truth; scientific method; scientific reasoning; paradigms; paradigm shifts; Janusian thinking; convergent thinking; divergent thinking; failures, successes, risks, and risk-taking in science; intelligence quotients and scientists; savants; geniuses; creativity; landmark scientific breakthroughs; scientists and resistance to scientific discoveries; semiotics; components of scientific breakthroughs; and Nobel awards and science. This search identified essential elements and commonalities that consistently appeared in the process of discovering a breakthrough and winning a Nobel Prize. A successful pattern of discovery consistently emerged when the scientific method was combined with personal qualities of creativity and insight. Journal articles and book chapters discussing the scientific method were used to elaborate and clarify the breakthrough process and identify specific functions common to this process.

An excellent edited book on insights, *The Nature of Insight* (Sternberg & Davidson, 1995), proved to be a very useful text for the first course. *The Nature of Insight* contains five divisions. The introduction reviews the history and methods of science while the second section explores how challenging puzzles, answers to which cannot be obtained through ordinary means, must have been solved. The third section examines ways in which people develop new inventions, and the fourth section discusses the thinking processes of several historically insightful people. The final section considers evolution and investment as metaphors for understanding insight.

A second book on creativity, *Creativity and the Mind: Discovering the Genius Within* (Ward, Smith, & Finke, 1999), was coupled with *The Nobel Prize: A History of Genius, Controversy and Prestige* (Feldman, 2000) to enrich the textbook content provided during the on-campus course before the students embarked on the Stockholm-based second course. A number of required and supplementary journal articles completed the list of course readings. Students were expected to synthesize the readings into a coherent explanation of scientific breakthroughs. The course faculty member thus encouraged students to develop a more holistic understanding of the fundamental components of a scientific breakthrough and the processes required to achieve one through advanced study of creativity and insights.

USING THE SCIENTIFIC METHOD AS A FOUNDATION FOR COURSE DEVELOPMENT

The different components and goals of the scientific method served as the foundation for integrating content into both the first on-campus course and the Stockholm-based course. Both courses examined thinking, reasoning, and problem-solving in relation to major and persistent questions in various sciences. In trying to determine why the findings from certain studies were deemed "breakthroughs" in science, students explored the nature and correlates of creativity and genius within the context of a scientific breakthrough. Both the semester-long course on campus and the subsequent international-study course in Sweden included discussions of Nobel Prize-winning investigations in chemistry, physics, and physiology/medicine; well-recognized examples of scientific breakthroughs and their Nobel Prize-winning recipients; and well-recognized examples of highly creative and successful scientists. At the Karolinska Institute and the Nobel Forum in Stockholm, scientists from a variety of fields conversed with students, describing their personal thoughts about what would constitute major breakthroughs in their fields of study. Although the international course in Stockholm would have been effective on its own, students were primed to obtain more meaning and impact by participating in the preceding semester-long course administered on campus. Likewise, the first campus course would have been useful by itself, but higher academic returns were realized through the symbiotic interaction of the two courses.

PRACTICAL ASPECTS OF COURSE PLANNING

The course faculty began preparing for the two-course sequence twenty-four months in advance. Twelve months were required to obtain formal course approvals from Penn State. Six months following the final course approvals, Part I was offered on campus, followed by Part II in Sweden.

While course approvals were being obtained, the course faculty, with the assistance of a colleague who had an adjunct faculty appointment at Karolinska Institute, and a Swedish nursing student who had worked alongside and knew many of the desired lecturers, initiated contacts with potential guest lecturers at the Karolinska Institute in Stockholm. Agreements with guest lecturers were not finalized until four months prior to the international course, which immediately followed the semester-long course at Penn State. Had the course faculty not had the critical assistance of the adjunct faculty from the Institute and the Swedish student, it is unlikely that sufficient and appropriate lecturers would have been obtained in time for the summer course in Sweden.

Dr. Richard Stoller, Coordinator of Selection and International Programs at the Schreyer Honors College, provided expert guidance in obtaining approval for the two honors electives within the Schreyer Honors College. He also paved the way for securing approval for "Stockholm Study Abroad" through Penn

State's international committee and for ensuring that the honors students' airfares and lodging were subsidized through a Penn State travel grant.

PUBLICIZING THE COURSE TO RECRUIT STUDENTS

Descriptions of the two scientific breakthrough courses were presented at an open house sponsored by the Schreyer Honors College. Faculty members offering new honors courses, or honors courses that tend to have low enrollments, met and spoke with students during this evening session two months prior to the start of spring term. Faculty members created their own color brochures for marketing their courses. The courses were also listed and described on the Schreyer Honors College web page and in the monthly Honors Newsletter sent out to all honors students. Because the Schreyer Honors College works hard to offer several international study courses each year, a special section was devoted to international honors courses. That section helped focus students' attention on course opportunities offered in specific countries, each with a particular academic focus. In addition, a one-page flyer announcing the Stockholm course was posted on bulletin boards in some of the student dormitories. The name, email address, and office phone number of the faculty member coordinating the Stockholm course was listed for students desiring more information. All of the publicity helped generate student interest and facilitate course registration.

PROGRAMMATIC TEMPLATE

To facilitate the approval of "Stockholm Study Abroad," two honors electives on "Scientific Breakthroughs and Nobel Laureates" were developed as a **programmatic template**. Part I was three credit hours and conducted on Penn State's University Park campus during the spring semester. Part II carried one credit hour and was held during the summer session in Stockholm, Sweden.

The **foci** of these sequential course electives were as follows:

1. searching for truths—techniques and approaches (including the scientific method),
2. different types of thinking,
3. intelligence and creative quests,
4. scientific breakthroughs, and
5. Nobel Prizes in the sciences.

The first three foci were emphasized most heavily in the first course. In searching for truths, the scientific approach—logical, associative, and causal reasoning—and paradigm shifts were discussed. Convergent, divergent, and Janusian thinking[1] were examined as different paradigms of thinking. In exploring intelligence and creative quests, students read and talked about intelligence quotients, *savants*, geniuses, and the generation of hypotheses.

The latter two foci were emphasized primarily in the "Stockholm Study Abroad" course held in Sweden. In studying scientific breakthroughs, students explored selected landmark breakthroughs in science; components shared by the majority of scientific breakthroughs; and uncertainty, perseverance, and the search toward greater certainty. Criteria for Nobel Prize awards, well-known Nobel laureates in the sciences, and scientific Nobel laureates' contributions to the development of science were addressed as part of the fifth focus of Nobel Prizes in the sciences.

OBJECTIVES FOR THE STOCKHOLM COURSE

The global objectives of the Stockholm course were to communicate and understand the following topics: creative thinking in science, promising research in science, examples of scientific breakthroughs, and scientific accomplishments of Nobel Laureates. The students' specific learning objectives included the following:

1. Examine pivotal details of various scientific breakthroughs in science;
2. Discuss where creativity can be identified in scientists' accomplishments of selected scientific breakthroughs;
3. Develop questions concerning opportunities for scientific breakthroughs with scientific investigators working at the Karolinska Institute;
4. Explore details of previous Nobel Prize recipients' careers in the sciences and their best-known studies provided at The Nobel Museum.

Readings for the Stockholm Study Abroad course included the book previously discussed on the Nobel Prize (Feldman), *Nobel Prize Women in Science* (McGrayne, 2001), and selected journal articles that had been placed on electronic reserve at Penn State's Paterno Library.[2] Specific assignments consisted of participation in seminars and field experiences, a written critique of all field trips, a written paper on one scientific breakthrough and one Nobel laureate, or a thought experiment on a topic relevant to the student's honors thesis research. An example of a biology major's scientific breakthrough and Nobel laureate paper involved Barbara McClintock's work with maize genetics and the action of transposable genetic elements. A chemistry student's paper on a thought experiment discussed scientific speculations about the best approaches for producing meaningful scientific research.

ARRANGING LECTURERS AND LECTURE HALLS

Teaching strategies included guest lectures, seminar discussions, readings, field trips, and other observational experiences at the Karolinska Institute. Lectures were conducted on the Karolinska campus, primarily in the Medical History Museum. For this international course, eleven lecturers represented physiology, neurophysiology, anesthesiology, genetics, endocrinology,

neurology, molecular biology, and library science. Had two additional weeks been possible, scholars from most, if not all, of the students' other major fields might have been included (economics, accounting, finance, animal science, electrical engineering, history, and international relations).

FIELD TRIPS

Field trips were taken in Stockholm and Uppsala. Some of the sites included Gamla Stan ("Old Town"); the centrally situated runestone at the junction of Kåkbrinken and Prästgatan in Gamla Stan; Vasterlanggatan (street famous for cafés, shopping, and tourism); Marten Trotzigs Grand (the narrowest and longest cobblestone street in Stockholm); the Medical History Museum; the Karolinska Hospital; The Nobel Museum; The Nobel Forum; Vasa Museèt (home of the famous warship from 1628 now located on the island of Djurgården); the Swedish Museum of Natural History; Norrmalm's Café Opera restaurant; Linnaeus' Botanical Gardens in Uppsala; Birka, Björkö archeological Vikings excavated site on Lake Mälaren; the Stadhuset (Stockholm's City Hall); the Stockholm Archipelago and famous waterfall sculpture; the Museum of National Antiquities; and the Royal Palace.

ITINERARY

The weekday itinerary included breakfast on the ship in Stockholm harbor (where students were lodged) from 6:30 to 7:15 AM; travel to the lectures from 7:15 to 7:50 AM; lectures from 8 until 12:30 or 1 PM; and field trips or sightseeing thereafter. Students were able to use the afternoons and evenings to pursue additional study and sightseeing in their specific areas of interest.

LODGING

For lodging, students stayed at two international hostels. These hostels were both aboard boats, one being the Gustaf af Klint and the other the af Chapman sailing ship moored in the central Stockholm harbor. Travel to and from all locations was accomplished via subway, buses, trains, and walking. Of the two hostels, the af Chapman provided the better quality of lodging whereas the Gustaf af Klint provided the most convenient location for access to the Karolinska campus and the Nobel Forum. Reservations for hostel lodging for groups should be made at least six months prior to arrival to guarantee adequate space.

OVERALL COSTS

The approximate cost of the trip for each student was $1420. Of that amount, airfare ($745) and lodging ($322) were covered by a travel grant through the Schreyer Honors College. Penn State Schreyer Honors Scholars are encouraged to pursue international coursework and are eligible for an exciting array of special programs. Approximately 100 Schreyer Ambassador Travel

Grants are awarded each year in support of international study, service learning, and research abroad.

RECOMMENDATIONS FOR FUTURE COURSE OFFERINGS

Honors students tend to be confident in pursuing graduate-level scholarship, connected to the concept of life-long learning, and motivated to set an example for improving practices in science and other disciplines. In both the on-campus and Stockholm Study tour course, students developed a deep understanding of the principles of science, including the confirmation, communality, competition, collegiality, and continuity of scientific work.

Every student who participated in the Stockholm Study Abroad course reported that the course was extremely valuable to his or her scholarly development in terms of major-specific development, cross-faculty exposure, and interdisciplinary collaboration. Should this or a similar series of courses be offered again, it would be useful to secure lecturers at least six to nine months in advance and allow students more opportunities for engaging in discussions with Swedish graduate students. Direct peer-to-peer contact might also entice more American honors students to think seriously about pursuing graduate study abroad. If undergraduate foreign coursework is not an option, a course such as the Penn State on-campus component is still desirable as a first step toward international research. Instilling interest in international learning and encouraging cross-faculty exposure at the undergraduate level can produce better-prepared graduate students and a more diverse, integrated network of global scholarship.

AUTHOR'S NOTES

[1] "Janusian" thinking involves the simultaneous mental resolution of two diametrically opposing ideas or views.

[2] Copies of the required and supplemental reading lists used in these courses are available by contacting the first author.

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APPENDIX

UNDERLYING TEACHING AND LEARNING ASSUMPTIONS FOR THE SCIENTIFIC BREAKTHROUGHS AND NOBEL LAUREATES COURSES

1. Much of the content contained in these courses will be relatively new to many of the students.
2. Content about the components of scientific breakthroughs will be useful to anyone interested in a career in one of the sciences as well as other disciplines.
3. The content in these two courses often approximates a graduate level of reading and interpretation more than an undergraduate level.
4. Many of the honors students are not adequately challenged in other electives. If more thinking and integration were expected in other electives, they would generate more important work.
5. Students are not likely to have been previously exposed to much of the content in these courses because other courses in the sciences focus nearly all of their time on scientific findings (content) within a particular domain rather than on the thought processes that went into developing those findings (process).
6. All of the class members are highly intelligent "A" students and leaders.
7. Class members represent a sampling of the sciences and other fields of study at Penn State.
8. Because class members are so intelligent, they catch on quickly. They also become bored more quickly than students who do not catch on and need information repeated.
9. Even though all of the students are intelligent thinkers, good speakers, and excellent writers, not all of them will necessarily enjoy sharing their thoughts openly with others in a community context.
10. Active participation is the best way for students to learn about developing insights and working toward a breakthrough.
11. "Local analogies" arise naturally when a diverse group of outstanding students from diverse backgrounds share their thoughts openly in a seminar-style format.
12. In discussions of science, the appearance of local analogies is probably the best way to stimulate scientific breakthroughs.
13. Students would learn more about breakthroughs if guest lecturers from a variety of fields of study attended class and shared their thoughts with the students.
14. It is never wise to underestimate the capabilities of a group of students who have been challenged with a supposedly "impossible" task; they may progress much further than originally deemed possible, and this outcome may be more desirable than that achieved by setting more "realistic," yet lower, standards.

15. Students will get more out of a course if they selectively focus on readings of interest to them personally than if the course faculty member gives them too much guidance and pigeonholes reading topics within his or her personal area of scholarship.