Articles
Lost in Translation?

DECONSTRUCTING SCIENCE IN THE NEWS THROUGH AN INQUIRY-BASED COURSE

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This report describes an experiment to introduce freshmen science students to inquiry-based learning. The overarching theme was the communication of scientific information to the public by the mass media. Students, working in groups, deconstructed news items (many dealing with basic biomedical issues) and assessed the veracity of statements with reference to published scientific literature. Working as individuals, they wrote news items about the work of researchers whom they had interviewed, who included among others biochemists, molecular biologists, physiologists, pharmacologists, neuroscientists, and nutritionists. This experience enabled freshmen to look critically at mass media, as well as the scientific literature. As this approach transcends disciplinary boundaries, it is relevant for educating future biochemists and molecular biologists.

Keywords: News items, popularizing science, peer review, active learning and undergraduate education, molecular biology education.

It is becoming increasingly apparent that research-intensive universities, at least in the North American context, can ill afford to neglect undergraduate education [1]. Inquiry-based learning, as emphasized by the Boyer report [2], provides a mechanism by which the excitement and fascination of science can be communicated to the junior-most students in the university setting. This can be achieved by getting students to appreciate that scientific knowledge is not just given but is actively constructed by scientists who in their working lives ask questions, find answers, and evaluate these answers in relation to what is already known. As this approach transcends disciplinary boundaries, fostering inquiry-based learning is as relevant for the teaching of biochemists and molecular biologists as it is for other sciences. In this regard, one of the champions of this approach has been Alberts [3], both in his capacity as an active researcher and teacher but also as the former president of the National Academy of Sciences.

However, inquiry-based learning is not easy to define [4 – 7]. Teachers in any university course could legitimately argue that whatever teaching they do is inquiry-based anyway, merely because they convey to their students new knowledge and information that is based on prior research. It is important, though, to consider the person who is doing the inquiry. Is it the faculty? Or the student? The inquiring student should then be the focus of inquiry-based learning. Dewey [4] emphasized that "inquiry is the controlled or directed transformation of an indeterminate situation into one that is so determinate in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole."

This report deals with an attempt to initiate first year students in a new undergraduate science program at the University of Calgary to inquiry-based learning. The O'Brien Centre for the Bachelor of Health Sciences Program offers a research-intensive honors degree program consisting of three majors: biomedical sciences, bioinformatics, and health and society. The courses are taught by different faculties with the view that contemporary health issues are best explored in a broad-based, interdisciplinary, active manner. The program structure is designed to provide students with a well-rounded background in health sciences that will enable them to pursue further opportunities in the global health care sector.

The students in each of the majors take courses that emphasize the particular character of their respective streams. Thus, the students in the biomedical stream take courses in chemistry, physics, biology, etc., whereas those in bioinformatics and in health and society have a higher concentration of courses in computer sciences and social sciences, respectively. There is flexibility enough to permit students to take cross-over courses, if they choose to. The three programs are underpinned by mandatory inquiry courses that culminate in a fourth year honors research thesis.

These inquiry courses are loosely termed "From Cell to

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Society" largely to give organizers the flexibility to tailor the content as they see fit. The process elements are to foster independence, self-direction, and critical analysis and to encourage group interaction and sharing of information. Here, I describe my attempts to design and coordinate the initial inquiry course for these students and reflect on the promises and pitfalls of such approaches.

Media coverage of scientific items provided the thematic anchor for this course. Modern scientific research is a cumulative, cooperative endeavor in which the public has a large stake. Although scientists can readily communicate with each other through their own formal systems of communication, these are relatively opaque to the public at large. The media play a crucial role in translating the arcane language of science into more meaningful and digestible words, often providing the public with their first glimpses of new discoveries. Even for practicing scientists, news items serve to alert them to developments not in their special areas of study. Media coverage of scientific issues has been severely criticized for being superficial, inaccurate, and sensationalized, and therefore, some crucial elements could be distorted [8, 9]. Thus, I felt that approaching the arcane language of science through the medium of news items would be easier for freshman. Hence, the central theme of the course was to deconstruct this exchange and assess whether much or little was **lost in translation.**

MATERIALS AND METHODS

Students—The class consisted of 76 students. Of these, 60 were freshmen who had completed 12 years of schooling and were selected on the basis of a combination of high school grades and a supplementary package. The rest transferred into the program from a senior year. Since none of the transfer students had done inquiry-based learning in this particular format, they were required to take this course.

Teachers—Most of the preceptors were basic scientists (with Ph.D.s in biochemistry, molecular biology, pharmacology, etc.) with the exception of one clinician and a social anthropologist. The basic scientists included the President of the University. Most had active research ob-ligations, and the sessions were scheduled in the evening to accommodate that element. They met students on a regular basis, guided them in their inquiry, assessed group logs on a regular basis, provided selected publications for critical analysis, graded that assignment, and participated in grading presentations.

Library Resource Person—A library resource person gave an initial orientation to available resources, prepared resource lists that were added to Blackboard (the server that was used for communication purposes), and was available to assist students.

Journalist—A well reputed journalist gave a general talk to the students about the role of the media and also marked the individual assignments.

Coordinator—As the coordinator, I designed the frame-work and evaluation procedures, read all individual logs and projects, and sought to act as a floating preceptor to oversee all groups.

THE COURSE (EDUCATIONAL GOALS)

The course, in common with other inquiry-based courses, had both content and process elements.

Content—Communication in science provided the thematic focus. The students were told that by the end of the course, all would have an appreciation of

a) the formal nature of scientific communication (particularly the format of research publications and the elements of peer review)
b) the role of the media in communicating science information to the public.

In addition, given the nature of the projects they under-took, each student would gather information about the specific scientific basis of the particular stories they investigated.

Process—Students were expected to acquire a set of skills that were relevant for inquiry-based learning. These included the abilities to

a) seek, critically analyze, and synthesize information from a variety of sources,
b) communicate that information to others,
c) monitor their own performance, and
d) gauge the performance of others in the group.

THE COURSE (IN PRACTICE)

To achieve the objectives, students were divided into 10 groups (7– 8 students per group). Each group had two co-preceptors who shared their responsibilities.

The classes were held once a week for a 3-h session in the evening (6 –9 p.m.). All groups met initially for about 15–20 min for announcements, etc., before dispersing with their preceptors. The preceptors were responsible for monitoring the progress of the group projects, ensuring that students shared responsibilities and were given opportunities to practice critical analysis of scientific publications.

The students had an initial orientation to the library, and the librarian was available to provide them help if they required. Each student participated in two exercises: a group project and an individual assignment (see later under "Evaluation").

Evaluation—Evaluation of student performance included both group and individual elements. Evaluation in inquiry-based courses is not easy. De Boer [10] has neatly summarized the inherent tensions between promoting student-centered learning and the accountability framework of a standards-based world. Giving the stu-dents flexibility within looser specifications and multiple evaluation items would to some extent ameliorate that problem. For this course, each student got a final grade (equivalent to 100 marks). These marks were accumulated by gauging their performance on both group and individual tasks.

Group Functioning—Group functioning was assessed in two ways. All students were expected to (i) participate in a group project (20 marks) and (ii) keep a group log (20

TABLE I - Course evaluation (MDSC 203)

Students were given a series of statements and were asked to indicate the strength of their agreement with each on a 5-point scale (1 disagree to 5 strongly agree). The numbers in the right-hand column are in the following order: **Mean**, *Mode*, Standard Deviation.

The course helped me appreciate the complexities underlying scientific communication.	**4.27**, *4*, 0.79
The course helped me appreciate the problems underlying media reporting on scientific issues.	**4.31**, *5*, 0.75
The course helped me identify the elements of a scientific publication.	**3.71**, *4*, 0.98
The course helped me recognize the difficulties in critically analyzing scientific publications.	**4.04**, *5*, 0.90
This course will help me read news articles dealing with scientific issues more critically.	**4.11**, *4*, 0.91
Group work was painful.	**2.59**, *1*, 1.38
The group logs were a waste of time.	**3.08**, *3*, 1.20
The personal logs helped me reflect on my learning.	**2.96**, *4* 1.24
Presentations helped me consolidate my learning.	**3.0**, *3*, 1.22
Random selection of presenters was a useful device to help us all learn.	**2.5**, *1*, 1.45
Listening to other presentations complemented my own learning.	**3.05,** *3*, 1.17
I enjoyed working on my individual project.	**3.55**, *3*, 1.20
It was exciting to interview research workers.	**4.03**, *5*, 1.02
The preceptors facilitated my learning.	**4.26**, *5*, 0.91
The course gave me a good introduction to the process of inquiry (asking questions, seeking, synthesizing, integrating and sharing information).	**3.68**, *4*, 1.07
The course provided a valuable learning experience.	**3.58**, *4*, 1.0

marks) as a record of their progress toward that goal. Each will be described separately below.

(i) The Group Project: Students were asked to

a) select a news item (hereafter called a story) concerning a scientific issue that had appeared in the media (newspapers, magazines, radio, TV),
b) identify the specific scientific elements or claims,
c) see whether those statements could be corroborated by acceptable publications,
d) assess the accuracy of the story, and
e) gauge whether much or little had been lost in translation. This project then got them to critically look at the way in which the media report scientific information.

Students were expected to present their observations to the class on a specified date (in the last 2 weeks of the term). To ensure that students had learned from each other, a student was chosen at random to represent the group, just minutes before the presentation itself. It was stressed repeatedly that all students should be familiar with the content of the presentation and that it was a group effort. The style of presentation of the individual chosen was not to be considered. Further, all students in a group participated in answering questions. The presentations were graded on the following criteria: clarity (6 marks); content (6 marks); comprehension (8 marks).

(ii) The Group Log: The group log was used by preceptors to monitor the progress of their particular group. These reports, which were to be handed in weekly, were to include the list of tasks, accomplishments, individual contributions, and annotated references.

Individual Work (60 marks)—Individual work included several different components, which were (i) a personal log, (ii) a critical analysis of a published paper, and (iii) an individual assignment.

(i) The Personal Log (10 marks): The personal log was meant to provide students an opportunity to reflect on their own learning. Students were asked to chart their progress in relation to the group and individual projects. They had to devise an evaluation scheme that best expressed their personal goals for this course. At the end of the course, students provided a summative evaluation of their performance and were given the privilege of allotting half of their grade. The other half of their grade was given by me.

(ii) Critical Analysis of a Published Paper (20 marks): Preceptors were asked to select a specific research publication in the particular scientific area that their group was investigating. Each student was required to submit a formal critical analysis of that report using specific guidelines [11].

(iii) The Individual Assignment (30 marks): The individual assignment was designed to make students move in the opposite direction to the group project. They were essentially to function like journalists. Thus, they had to

a) select a research worker at the university,
b) familiarize themselves with their work by reading their publications,
c) interview them, and
d) finally, "translate" their work into lay parlance in the form of a journalistic report. The report was also to include a personal reflection of the process by which they accomplished this task, as well as a list of annotated references. The grading emphasized the journalistic item (20 marks) assessed on three criteria: clarity, content, and comprehension. The personal reflection and annotated bibliographies were allotted 5 marks each.

RESULTS AND DISCUSSION

The success or failure of this experiment can be gauged from two perspectives, that of the students and mine. I used several sets of data in assessing this course: the results of a questionnaire given to the students at the end of the course, the comments made by students either in their personal log or in private, some comments from preceptors, and my personal observations. Of these, I would use the data from the questionnaire (Table I) as the primary source and modify these based on the other sets of information. The questionnaire, filled out anonymously, provided the widest spectrum of responses, and compliance was 100% as it was emphasized that this was an obligation.

Group	Topic Considered	Source
1	Autism and MMR vaccine	BBC news
2	Math learning	Newspaper
3	Safety of pertussis vaccine	Newspaper
4	Prozac and child suicide risk	BBC news article
5	Hepatitis B vaccination and MS	Newspaper
6	Health effects of beer and wine	Newspaper
7	Health effects of sugar	Popular magazine
8	Embryonic stem cells	Speech reported in newspaper
9	Designer steroids	Newspaper
10	Cloning woolly mammoths	Newspaper

In addition, each student who took the course had to complete both group and individual tasks, as de-scribed below.

Group Tasks—As described earlier, the objective of the group tasks was to give students the opportunity to look critically at media reporting of scientific information. A list of the topics covered by the different groups and their starting sources are shown in Table II. Although there were some variations, most students selected text-based material either from newspapers or from magazines, and there was an obvious biomedical flavor. This was inevitable given the interests of the students and the background of the preceptors. Most groups approached their task with zeal and enthusiasm. The extent to which some groups went to corroborate and track down information was quite impressive. The annotated references supplied also showed that the students had read a variety of sources.

The paths taken by one particular group are described below. They began by considering a number of articles before whittling them down to a set of 12 from which they chose one. This was a newspaper item dealing with the learning of mathematics. They read the item numerous times to understand the details. They contacted the journalist (who was specializing in science writing) to get his perspective and the particular sources he had used. They reread the article and underlined the sentences and phrases from the sources. They cross-checked the sources cited to determine whether these corroborated what was written in the newspaper item. One of the members of the group found a draft version of the same news item, so they had two versions to compare. They realized that the editorial changes had not only eliminated some scientific statements but sensationalized it to make it newsworthy. They assessed the readability of the two versions of the news items, as well as the original articles from the scientific journals. They found that the final published news item was the easiest to read. They concluded that the journalist had accurately portrayed the science behind the story, had extensively researched his topic, but had to submit to editorial decisions that actually made the item easier to read, although it sensationalized it as well.

A student’s performance on this component was evaluated in two ways: by submission of a group log, monitored exclusively by the preceptors for that particular group, and by a group presentation assessed by all the preceptors and the course coordinator. Each will be de-scribed separately below.

(i) Group Logs: These were meant to chart the progress of individual groups and were a means by which preceptors could keep track of individual contributions. This component received mixed ratings (see Table I). The preceptors had been given clear guidelines, but there was some variability in the interpretation of these, leading to considerable dissension. Some preceptors followed the guide-lines given and held their charges accountable for ongoing performance. Others were a little more casual, and this was seen to be a sign that slackers were being unfairly rewarded. Students were quite vocal about their dissatisfaction, as the following quotes show: “Group log doesn’t really helped much [sic], I don’t think any members actually reviewed and looked at it,” “the group log wasn’t that useful,” “discontinuity (sic) when it comes to differences in marking between groups,” and “lessen the amount of work needed for group logs.” In addition, a number of students clearly said that group logs should be expunged. Some students resented the fact that they were made to write. “I did not like the writing involved, I am good in sciences, not English.”

Although I was aware of these sentiments, I found it difficult to intervene midway through the process as I had permitted preceptors to grade these components. My initial hope that I could act as a floating preceptor for all groups was dashed as I had to substitute more than once for a single preceptor, the President of the University. The students appreciated his comments when he was present since he was able to probe them critically and get them to test their assumptions. Unfortunately, he had many other obligations, although he did give the students useful comments on their presentations and projects. However, my inability to meet with all groups regularly was a source of some resentment, as gauged from comments in the personal logs. The grades allotted to the group logs were a substantial portion of the course, and the discontent over grades really colored student perceptions. Even several months later, the students raised this component as a serious shortcoming of the course as a whole.

Another contentious issue was the role played by the senior students. The 16 students were evenly distributed among the different groups. Since none of these students had done inquiry-based courses earlier, it was mandatory to take this course. The majority of the senior students adjusted well, although a few were quite resentful of their younger counterparts. They felt quite strongly either that they should not have been made to take the course or that they should have a separate group to themselves. These feelings were openly expressed, particularly in the personal logs. The final grades did not bear out that perception. Although clearly some of the senior students per-formed extremely well, others did not.

(ii) Group Presentations: Although students were per-mitted to give their presentation in any format, all chose to use PowerPoint. This was driven in part by their comfort with computers and encouragement by preceptors and an unwillingness to be found wanting if they used simpler technologies such as overheads. Although I had repeatedly emphasized that what was required was content, clarity, and comprehension, it was clear that many groups had spent an inordinate amount of time on glitz and glamour. In some cases, this did not detract from the material, but in others, it clearly did.

Another problem was that the presentations were marked by all the preceptors and the grades were aver-aged. There was clearly dissension regarding the course expectations. Although some preceptors stuck closely to the guidelines, other groups went into far greater detail about the scientific components. Given that the majority of the students were freshmen, this placed undue stress on the students as they were "brought up to speed," to use the words of one preceptor. Although most groups did well, there were a few that did not. These groups felt that they had been let down by the person chosen to present, by their preceptors who had improperly guided them, or by the unfairness of the questions asked. The comments of all the preceptors were collated and returned to the students. I was careful enough to eliminate censorious comments, but even mildly negative ones rankled. A group was com-mended by one preceptor for being clear and analytical, whereas another criticized the lack of science content! Even the group whose work I had described earlier received mixed ratings, although they received the highest grades overall for their effort. One preceptor noted that their "presentation of edited *versus* unedited articles was very smart," whereas another commented, "Very analytical, thus a bit less interesting." Another group felt quite upset that the grades they received ranged widely in com-parison with other groups. One student stated it quite bluntly, "Many of the preceptors seemed to have different takes on what the purpose of the assignment was. I wonder why the comments on the presentations varied." An-other said, "The biases of the preceptors were blatantly obvious."

Although I had repeatedly cautioned students, it was evident that some groups had spent far too much time adding glitz rather than content. These students were quite disappointed that what they perceived to be blander presentations scored higher. This added to dissatisfaction with the evaluation process in general. Nevertheless, the students clearly learned from listening to the presentations, as seen from the data provided in Table I.

The random choice of presenters was not appreciated by the students (Table I). However, the scores ranged from 1 to 5 for this component, suggesting that at least some students liked it. One student who was chosen wrote the following comments: "I was chosen to present on behalf of my group—what luck—thank goodness I was ready for it! . . . I have learned a very important lesson this semester: you must be flexible— dealing with new and uncomfortable situations *i.e.* presentations, requires [sic] a great deal of flexibility. I'm glad I learned this in the first inquiry course." To actually get them used to the notion, I scheduled an interim report from all groups and used random draws in that instance as well. Ironically, two of the students drawn the first time were picked the second time as well. The students felt it added undue stress, and some felt strongly that they could have done a better job than those who were actually selected. In other courses, where I had used a similar approach, students did find it stressful but really appreciated the opportunity to test their mettle under demanding situations.

Individual Tasks—Among the items used to gauge individual performances were the personal logs, a critical analysis of publications, and the individual assignments. Each will be considered in turn.

(i) Personal Logs: Personal logs were included as an opportunity for students to monitor their own progress and practice self-reflection. I gave them considerable liberty to develop their own evaluation criteria. To encourage them to do so, I posted my own log on a weekly basis. A number of students took this exercise seriously. What they wrote in their logs showed clear evidence of learning and self-reflection. I picked up the logs on a random basis, read them, and scribbled comments. I found the logs to be useful pointers. Students often expressed their frustrations with their groups and gave me clues about dysfunctional groups long before problems surfaced. One student noted, "Being asked to complete a personal log . . . at first seemed like an easy 10% . . . Over the next few weeks, it became apparent that the log was not the easy task it had appeared to be."

However, not all students took this item seriously, and a number were quite irritated with the process, feeling it was quite juvenile. One student wrote bluntly that in some weeks, there was really nothing to write and "forcing my-self to write something only made me greatly dislike the log." Another sniffed at the whole approach, stating that "teachers have always stressed the importance of logs in the same way, but I don't believe that the learning gained from reflection was worth the expenditure of time." I had used this approach in other courses, and although feelings were quite mixed, the resentment expressed here was more blatant.

(ii) Critical Analysis of Publications: The objective of this exercise was to introduce students to one of the cardinal signs of modern scientific practice—the peer-reviewed scientific publication. This particular aspect was left to the preceptors to discuss with their respective groups. I expected that by participating in this exercise, each student would get to recognize the format of the standard research publication and get some feel for the problems inherent in peer review. Since most students were in their first term at university, it was difficult to expect them to have a detailed knowledge of methods and techniques to criticize papers in depth. To make it easier for them, preceptors were requested to choose publica-tions in the specific areas that the students were exploring for either their individual projects or their group projects.

The process did not work optimally. The variability in preceptors posed a problem. Some preceptors took their tasks seriously and ensured that the students in their group were given due attention. They gave them opportunities to practice and spent considerable time with them. This also meant that they were able to recognize good and poor performances, which also meant that some students got higher grades. Other preceptors took this more casually and did not discriminate adequately. This, too, became a contentious issue with the students since some felt that they were in a tougher group, whereas others got away lightly. Nevertheless, all students were exposed to the format of research publications and a discussion of the peer review process. Ironically, they got a taste of some of the problems inherent in peer review when they got the comments from the different preceptors following the group presentations. When students were quite surprised that the same presentation evoked so many different opinions, I reminded them about the variability one gets from external reviewers of either grants or papers.

(iii) Individual Projects: Students were asked to contact research workers in the university. I had tried to make their task easier by sending out a notice through the faculty server asking for volunteers to talk to my students. A number were quick to respond, and a list of those who were willing, along with their research areas, was given to the students, although many students obtained contacts on their own by tracking research workers through diverse sources.

Given the nature of the program, most students focused their attention on scientists doing either basic biomedical or clinical work. This included, among others, biochemists, molecular biologists, endocrinologists, oncologists, physiologists, pharmacologists, neuroscientists, and nutritionists. However, there were some who strayed farther afield and found mathematicians, botanists, psychologists, and economists. One student interviewed a researcher in education who was developing a mobile, portable system for distance learning. Most students presented their reports in the form of a newspaper or a magazine article, although two students produced videos. In a few instances, more than one student had interviewed the same person, and it was very interesting to see the different reports that emerged.

The assignments were coded by student ID numbers and judged by three independent assessors. A practicing journalist and I read all of them. The reports were divided and apportioned to five other preceptors. The grades were averaged. Although the actual grades given varied, the rank orders were consistent, and thus, the average grades given were a fair assessment.

The quality of the reports varied. Most students took their assignments seriously. Some were quite outstanding. One student had actually had her report published in the local newspaper in her hometown prior to submission. The journalist was very impressed with the quality of the final reports as well as with the detailed reflections submitted. This exercise also proved to be a good public relations exercise for our fledgling program. Many scientists who were contacted were quite flattered and also impressed with the professionalism of the students.

This was the most palatable of all the assessment procedures used. Most of the students were comfortable working on their own. The petty irritations of working with others were removed, and students could essentially organize their own time. They relished the opportunity to talk to research workers in disparate areas (see Table I). One student wrote, "I found about the lives of researchers and realized that the main reason they love their career is because they are making a difference in the world. I am excited about this . . . I am thankful for having this opportunity . . . helped me reinforce the belief I have that re-search is the career for me."

Coda—This report describes an experiment to initiate students to inquiry-based learning. Although the emphasis was on process elements, the content anchor was communication. The results show that the students felt that the course helped them appreciate the complexities underlying scientific communication. They recognized the problems faced by the media in reporting scientific information and felt confident that they would read news articles more critically. One wrote, "I soon realized that I should never believe what is written without researching the topic on my own." Another wrote that participating in the individual exercise gave them a better appreciation of the work that journalists do: "Maintaining one's journalistic integrity is much easier said than done. Journalists are required to meet deadlines and adhere to word limits. Their stories must also be appealing . . . " They also were able to recognize the elements of a scientific publication and realized that critically assessing such publications was not easy. More heartening for me was their recognition that the course gave them a valuable learning experience and a good introduction to the process of inquiry.

However, there were clearly elements that did not work satisfactorily. The large number of preceptors made it difficult to provide a uniform experience. Many were deeply committed and were very helpful to their groups (evidence seen in Table I). They were all active researchers with many other obligations and still made themselves available for these first year students. Unfortunately, uniformity was difficult to maintain, and matters came to a head in some situations. Further, the number of disparate assessments used was confusing and not really helpful. I had initially felt that by having several assessment items, students could have a better opportunity to do well on some that exemplified their strengths. This created more confusion and anxiety. All these factors will have to be considered when the course is offered again.

It is quite obvious that in redesigning the course, I should be far more explicit about my expectations, communicate more clearly with the students, have fewer preceptors, and ensure that each student is able to critically assess the literature. The emphasis on PowerPoint presentations will have to be reduced since students mentioned that far too much time was spent in adding glitz and glamour rather than content. I aim to stand firm on the random selection of presenters since that has worked well in the past and ensures that students do contribute to each other's learning. The issue of personal logs is a touchy one. They are clearly excellent vehicles for self-reflection for those who choose to use them properly, but persuading students that it is valuable is not easy, and I may have to either concede defeat on that issue or make drastic changes.

The theme itself, communication in science, is an important one and needs to be dealt with. Whether a first year course is the most appropriate point is debatable, although I would argue that the sooner students get to look at information critically and recognize the social nature of the scientific endeavor, the better they would be prepared for scientific careers in later years. The elements of this course can be readily adapted for courses in biochemistry and molecular biology. A number of the topics considered by the students had a biochemical flavor, and the scientists interviewed included biochemists and molecular biologists.

I mentioned at the onset that the term inquiry-based learning is difficult to define; the students who took this course participated in the inquiry process. To paraphrase Dewey [4], everyone who successfully completed the prescribed tasks began with an indeterminate situation. They sought, synthesized, and integrated information, as well as reflected on the learning process itself. Whether the final product they produced became a unified whole is not easy to say, but even Dewey was conscious that to term the end points of inquiry to be knowledge or belief suggested a finality that may not be appropriate. He preferred the term "warranted assertibility" since that suggested "a potentiality rather than an actuality," implying that "all special conclusions of special inquiries are parts of an enterprise that is continually renewed or a growing concern." The students who completed this course recognized the problems inherent in communication not only between scientists but between scientists and the public. This recognition itself signals that they participated actively in the inquiry process.

One student wrote in the final log,"all my hard work was not done out of obligation or a competitive nature, but instead I was hooked by the idea of self-directed learning and was addicted to the opportunity to finally research issues of interest to me. I couldn't stand another tortuous lecture . . . "

I would like an anonymous respondent to have the last word. This student, commenting on the feeling prevalent in the class that the guidelines were unclear, wrote that giving too much information "limits how people interpret and in turn do the task at hand . . . people who complain about the lack of details do not see the benefits and successes they have made discovering what they feel is the key issue-inquiry is a stepping stone in self-discovery, whether people realize it now or later on in their lives."

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