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An Undergraduate Toxicology Seminar Focusing on Ethical Reasoning and Communication Skill Development

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Abstract

The development of an undergraduate major in toxicology at Nazareth College provided the opportunity to develop a one-credit Principles of Toxicology Seminar designed to address ethical reasoning skills and communication (both oral and written), areas which can be challenging to address in traditional courses and which have been noted to be areas of deficiency in toxicology graduates. The seminar is a co-requisite to Principles of Toxicology, the introductory course in the major, and is built around the study of 5-7 environmental issues selected by the students. The issues are introduced through readings, documentaries, and student small group oral "environmental issue presentations." Students then write "policy papers" through which they survey the primary literature to determine the health effects of the chemical(s) implicated in the issue and make a determination of whether they believe the data support the current exposure limits set by regulatory agencies. Student evaluations of the seminar using the IDEA metric indicate substantial progress on objectives related to critical thinking and oral and written communication skill development, among others, as well as overall very positive views on the seminar itself and the field of toxicology. Thus, this seminar may serve as a pedagogical model of a course that engages students with real-world environmental issues of interest to them, while facilitating the development of the ethical reasoning and communication skills that can be challenging to address in the traditional curriculum.

Keywords: toxicology, undergraduate, seminar, ethical reasoning, critical thinking, oral communication, written communication, environmental issues

Introduction & Rationale

The development of a B.S. in toxicology major within the Biology Department at Nazareth College, a private liberal arts college of ~2,300 undergraduate students located near Rochester, NY, provided the opportunity to develop a sequence of new courses. One such course that was developed is a seminar focused on ethical reasoning and scientific communication skills that serves as a co-requisite to Principles of Toxicology, the introductory course in the toxicology major curriculum.

Principles of Toxicology Seminar is described in the course catalog as "an introduction to toxicological research in which specific environmental issues serve as the basis for the study of the effects of chemical exposure on human health as explored through primary literature analysis." The seminar is worth one credit and meets once weekly for two hours. The prerequisites for the seminar include a year of majors-level introductory biology (including labs) and one semester of majors-level general chemistry (including labs), thus most students in the seminar are third- or fourth-year students. In addition to serving as a requirement for toxicology majors, the seminar also serves as an elective of interest to biology, biochemistry, chemistry, biomedical sciences, public health, and environmental science and sustainability majors.

Principles of Toxicology Seminar was developed using a backward-design process by which it was built around specific goals (learning outcomes). Pedagogical approaches were developed by working backwards from these goals. The seminar was designed to meet specific departmental learning outcomes and address identified deficiencies in toxicology education, through the use of proven, high-impact practices. The Biology Department at Nazareth College has defined ten program student learning outcomes (PSLO's) that are woven into courses throughout the curriculum (Table 1). Principles of Toxicology Seminar was designed to address learning outcomes that had proven more difficult to integrate into more traditional courses, such as those related to ethical reasoning (PSLO #10) and written and oral communication skills (PSLO's #7 & 8) (Table 1). Indeed, developing better communication skills in science majors in general has been an area of concern for many undergraduate educators[1]. Additionally, participants in Society of Toxicology's Educational Summit, convened to address the state of toxicological education at all levels, identified critical thinking and oral and written communication skills as areas of deficiency in recent toxicology graduates[2]. Thus, addressing these deficiencies in toxicology majors (as well as life sciences majors in general who take this seminar) was a primary goal of the seminar as well, and led to defining four seminar student learning outcomes (SSLO's) (Table 2). To achieve these outcomes, the seminar was designed to utilize high-impact practices as defined by the Association of American Colleges and Universities (AAC&U), such as writing intensiveness and collaborative assignments, which have been shown to be valuable for students from a variety of backgrounds[3].

Nazareth College Biology Department Program Student Learning Outcomes (PSLO's)	
1	Describe and analyze biological phenomena at the cellular level
2	Describe and analyze biological phenomena at the organismal level
3	Describe and analyze biological phenomena at the ecological level
4	Describe the central role of evolution in biology
5	Perform the basic laboratory skills of observation, measurement, recording of data, and analysis of data
6	Use the scientific method to address the student's own biological questions in the laboratory, field, or literature
7	Demonstrate competency in scientific writing through formal assignments
8	Present research data and analysis in written, visual, and oral formats to biologists and/or the general public
9	Acquire competency in laboratory safety relevant to each laboratory course
10	Exhibit ethical reasoning and action, which encompasses one or more of the following: scientific integrity in data collection, analysis, and reporting; cooperation with others in teams; animal and human safety; and appropriate use of biological knowledge

Table 1. Nazareth College Biology Department Program Student Learning Outcomes (PSLO's).

Principles of Toxicology Seminar Student Learning Outcomes (SSLO's)		
1	Find and analyze relevant toxicological data from the primary literature	PSLO #5
2	Demonstrate critical thinking about specific issues in toxicology	PSLO's #1-3, 10
3	Effectively communicate information regarding environmental issues in both written and oral format	PSLO's #7 & 8
4	Exhibit an understanding of the complexity of regulatory issues in toxicology and demonstrate ethical reasoning in considering such issues	PSLO #10

Table 2. Principles of Toxicology Seminar Student Learning Outcomes (SSLO's). Note that each SSLO is linked to one or more Program Student Learning Outcomes (PSLO's) as defined in Table 1.

Seminar Format

The seminar group (~12 students) selects 5-7 environmental issues (e.g. hydraulic fracturing, mountain top mining, genetically modified organisms, offshore drilling, pesticides, endocrine disrupting chemicals, landfills, etc.) to study throughout the semester. Student evaluation in the seminar is based on the graded assessments outlined in Table 3 and described in detail below. The first seminar is devoted to selecting issues of interest to the students and reviewing how to find appropriate primary articles. Students then complete an assignment involving finding primary literature related to a specific toxicological issue that is worth 20 points.

Seminar Graded Assessments	
Finding Primary Articles Assignment	20 Points
Environmental Issue Presentation	50 Points
Policy Paper #1	50 Points
Policy Paper #2	50 Points
Policy Paper #3	50 Points
Attendance & Participation	20 Points

Table 3. Seminar Graded Assessments. Criteria used to determine students' grades in the seminar.

Each environmental issue selected by the group is then studied over a two-week period. The issues are introduced through documentaries and readings in the first week, and then small group oral "environmental issue presentations" in the second week. Environmental issue presentations focus on the chemical(s) involved as well as the social aspects of the issue (exposed populations, economics) and current policy (if any) regulating exposure (Table 4). As part of the oral presentations, the student groups pose discussion questions to the class and students are awarded participation points for their contributions to these discussion. Students participate in one environmental issue presentation that is worth 50 points. Presentations are evaluated by the instructor, using a rubric adapted from Table 4. Anonymous peer feedback is also provided to the student presenters, although this feedback is not included in students' grades.

Environmental Issue Presentations	
Overview	The presentation should begin with a brief summary of the issue
Historical Context	The issue should be placed within an historical context
Pros and Cons	Pros and cons should include social, economic, etc.
Toxicological Information	Relevant toxicological information should include the structure of chemical(s), routes of exposure, and ADME processes (data regarding health effects of exposure should be limited in the presentations since this will be the primary focus of the policy papers)
Current Laws	Current regulation in the United States and worldwide should be addressed
Discussion Questions	At least eight questions should be posed to the class for discussion
References	References should be formatted using the Council of Science Editors (CSE) Name-Year system. Citations should be included within the slides themselves (after each bullet point) and a reference list should be included at the end of the presentation. Each and every statement in the paper that would not be considered "common knowledge" of the audience (assumed to be fellow undergraduate science majors) should contain a citation.

Table 4. Environmental Issue Presentation Requirements. Presentations are designed to challenge the class think critically about specific issues in toxicology by building on the readings and introductory documentaries. Presentations are led by groups of students and are approximately 45 minutes in length. Presentations are worth 50 points.

Students next write "policy papers" that delve more deeply into the issues introduced in class, particularly with respect to the scientific data related to health outcomes found in the primary literature. Policy papers include an overview of the issue and chemical(s) in question and an analysis of five primary articles that they have selected related to the health effects of the chemical(s) (Table 5). The papers culminate in a decision by the students regarding how they would regulate exposure to the chemical(s) in question, if they were part of the regulatory agency tasked with making this decision. Students write three policy papers that are worth 50 points each. Policy papers are evaluated by the instructor, using a rubric adapted from Table 5.

Policy Papers	
Overview	The paper should begin with a brief summary of the issue (2 ¶)
Pros and Cons	Pros and cons should include social, economic, etc. (2 ¶)
Toxicological Information	Relevant toxicological information should include the structure of chemical(s), routes of exposure, and ADME processes (expanded from presentation to include half-life of the chemical(s) in question as well as examples of metabolites generated) (3 ¶)
Analysis of Data Regarding Health Effects	An analysis of the scientific data regarding the toxicological effects of the specific chemical(s) involved in the issue (citing at least five articles from the primary literature not cited in the presentation) which should include the following (3 pgs.): • An overview of how the study was conducted • Model systems utilized • A summary of the results • Implications of the study
Recommended Regulation	An overview of current regulation in the United States and worldwide should be included, as well as your recommendations which should include the following (2 pgs.): • Based on your evaluation of the available data, would you permit exposure to this chemical? Why or why not? • If you would, what exposure levels would you permit? • Would these limits be the same for all populations? Why or why not? • Are further experiments necessary? • If so, what types of studies should be done?
References	References should be formatted using the Council of Science Editors (CSE) Name-Year system. In addition to the five articles from the primary literature, it will also be necessary to cite other sources such as review articles, essays from the text, or government or academic. Each and every statement in the paper that would not be considered "common knowledge" of the audience (assumed to be fellow undergraduate science majors) should contain a citation.

Table 5. Policy Paper Requirements. Policy Papers challenge students to consider the environmental issues presented in the readings, documentaries, and presentations from the point of view of a government agency tasked with regulating toxicant exposure levels in the environment. Students select three of the seven policy papers to submit, however the first policy paper must be submitted in order to receive early feedback. Students have the opportunity to revise their first paper. Policy papers are approximately 6-8 pages in length (typed, double-spaced, with pages numbered). Each policy paper is worth 50 points.

Student Assessment of Achievement of Seminar SLO's

Principles of Toxicology Seminar has been taught eight times over the past six years. Of the eight sections taught, five sections (62 students in total) evaluated the seminar using the IDEA metric (https://courseevaluationsupport.campuslabs.com/hc/en-us/articles/360037910354-IDEA-Learning-Essentials-Form)[4], Nazareth College's campus-wide course assessment platform. When students were asked to rate the extent to which they agreed with the statement "Overall, I rate this course as excellent," on a 1-5 scale (1 = definitely false; 5 = definitely true), the mean rating was 4.5 (data not shown). When asked the extent of their agreement with the statement "As a result of taking this course, I have more positive feelings toward this field of study," the mean rating was 4.6 (data not shown).

While strong agreement with these broad statements indicates that after taking the seminar students felt overall very positively about it and field of toxicology in general, further efforts were made to parse the responses to better understand what specific aspects of the seminar students believed to be most beneficial. To this end, students were also asked to score progress on potential course objectives using a scale of 1-5 (1 = no apparent progress; 5 = exceptional progress) (Table 6). Note that as the IDEA metric is used for many disciplines, the objectives are broad-based competencies applicable to many fields and all are not equally relevant to the learning goals of this seminar. However, a number of objectives align closely with the SSLO's and thus these are the focus of this analysis. Notably, the mean rating for "Developing skill in expressing myself orally or in writing" (objective #8) was 4.4. While there is no objective that specifically addresses ethical reasoning skills, the mean rating for the objective "Learning to analyze and critically evaluate ideas, arguments, and points of view" (objective #11) was 4.4 as well. Both of these objectives are fundamental goals of the seminar and may be linked back directly to learning outcomes for the seminar (Table 2; SSLO's #2-4).

Objectives such as "Gaining factual knowledge" (objective #1), "Learning to apply course material" (objective #3), "Developing specific skills, competencies, and points of view needed by professionals in the field most closely related to this course" (objective #4), and "Learning how to find and use resources for answering questions or solving problems" (objective #9) were also rated highly (≥4.4), indicating that many of these skills are developed through the seminar as well, albeit perhaps less explicitly.

Student Ratings of Learning on Potential Objectives Using the IDEA Metric			
	Objective	**Mean**	**S.D.**
1	Gaining factual knowledge*	4.5	0.27
2	Learning fundamental principles, generalizations, or theories	4.3	0.19
3	Learning to apply course material*	4.5	0.14
4	Developing specific skills, competencies, and points of view needed by professionals in the field most closely related to this course*	4.5	0.22
5	Acquiring skills in working with others as a member of a team	4.3	0.48
6	Developing creative capacities	3.9	0.23
7	Gaining a broader understanding and appreciation of intellectual/cultural activity	4.0	0.21
8	Developing skill in expressing myself orally or in writing*	4.4	0.08
9	Learning how to find and use resources for answering questions or solving problems*	4.5	0.14
10	Developing a clearer understanding of, and commitment to, personal values	4.1	0.23
11	Learning to analyze and critically evaluate ideas, arguments, and points of view*	4.4	0.12
12	Acquiring an interest in learning more by asking my own questions and seeking answers	4.3	0.10

Table 6. Student Ratings of Learning on Potential Objectives using the IDEA Metric. Students were surveyed at the end of the seminar using the IDEA metric (https://courseevaluationsupport.campuslabs.com/hc/en-us/articles/360037910354-IDEA-Learning-Essentials-Form)[4] and asked to score progress on each potential course objective using a 1-5 scale. Reported means and standard deviations (S.D.) are calculated from responses of five sections (62 students in total). Key: 1 = No apparent progress, 2 = Slight progress, 3 = Moderate progress, 4 = Substantial progress, 5 = Exceptional progress. * indicates a mean rating of 4.4 or 4.5 (the highest ratings achieved).

Conclusions & Future Directions

Overall, Principles of Toxicology Seminar appears to be accomplishing the goals of developing students' ethical reasoning and critical thinking skills, as well as written and oral communication skills, areas which can be difficult to address in traditional courses. Offering a one-credit student-led seminar such as this may provide for students an interesting, thought-provoking way to develop these essential skills while engaging with real-world environmental issues.

Going forward, because the IDEA instrument does not directly assess progress on objectives related to ethical reasoning skill development, methods to address this essential objective more directly are being considered. Also, because the IDEA system measures only students' perception of what they've learned in the seminar, additional pre- and post- assessments that

evaluate actual student gains in measurable outcomes are being developed in an effort to continually improve the model for this seminar.

Notes

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