Foundational Concepts in Undergraduate Toxicology – Applying Vision & Change to the Development of Core Competencies and Learning Objectives for an Undergraduate Toxicology Course

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ABSTRACT

In 2011, the National Science Foundation and American Association for the Advancement of Science produced the “Vision and Change Report” (visionandchange.org) which sought to improve education in undergraduate biology for all students by defining Core Concepts: Evolution; Structure and Function; Information; Exchange and Storage; Pathways and Transformations of Energy and Matter; and Systems. Vision & Change has had a major impact on undergraduate biology education, scientific societies have created and adopted their own Core Concepts for their undergraduate courses and communicated them via peer-reviewed publication. Appointed by the Undergraduate Education Subcommittees and composed of experienced undergraduate educators, the goal of the Learning Objectives Work Group is to implement Vision & Change for undergraduate toxicology and to communicate its findings internally within the Society of Toxicology and externally via collaboration with multidisciplinary organizations including Course Source (coursesource.org), the Life Science Teaching Resource Collection (lifescr.org), and peer-reviewed publication. Data were collected and analyzed from more than 20 undergraduate toxicology syllabi from across the United States together with several undergraduate textbooks to quantify themes taught in all toxicology-related courses. A Learning Framework with Five Core Concepts was comparable to Vision & Change was developed: Evolution; Pathways and Transformations of Energy and Matter; Systems Toxicology; Biological Information; and Risk Assessment. Society Learning Goals for the Five Core Concepts of the Learning Objectives associated with each Society Learning Goal were also created. Publication of this framework alongside those of the other science disciplines will facilitate the development and sharing of evidenced-based teaching materials for toxicology educators throughout the world and expand toxicology’s impact to a broader audience.

INTRODUCTION

Course Learning Objectives are goals around which a course is organized, defining the demonstrable knowledge and skills that a student should learn having taken the course. Well-crafted Learning Objectives enable consistency in curriculum and enable sharing of content by faculty members from different institutions. The Vision & Change Work Group analyzed syllabi submitted by undergraduate educators via the Undergraduate Education Network (UEN) of the SOT and performed an analysis of trends in course content for a variety of undergraduate toxicology courses, including those focused on human health, environment, public health, industrial hygiene, forensics, and pharmacology. Although several core concepts were specified content specific to their subspecialties, consistent themes emerged from the courses that enabled the Work Group to define the Five Core Concepts. This work focuses on the shared themes of the diverse courses within toxicology with a recognition that faculty members will choose specific learning objectives for emphasis, depending on the type of course they are teaching.

In addition to working within the discipline of toxicology, Work Group members investigated course learning objectives that were produced by other scientific societies for their own undergraduate courses or majors. A common thread was their reliance on the National Science Foundation’s "Vision and Change: Education – A Call to Action", published in 2011. This report has served as the foundation for the development of consistent, interdependent learning objectives in life science. Based on the Work Group used Vision & Change as the framework for the development of learning objectives. The core concepts of the developmentally uniquely-designed coherent framework of objectives for developing undergraduate toxicology courses within an institution, taking into consideration the foundational sciences that support it.

CORE CONCEPTS IN UNDERGRADUATE TOXICOLOGY

- Evolution – Evolution drives the interplay between toxicants/toxins and xenobiotic defense mechanisms and justifies the use of model organisms
- Biological Information – Differences in genomes and environmental exposure drive differences in susceptibility and responses to toxicants
- Risk Assessment and Risk Management – Epidemiology and historical events together with science drive regulatory responses to risk to individuals and the general public
- Systems Toxicology – Toxicants affect cellular, organ, individual, and ecological systems
- Pathways and Transformations for Energy and Matter – Interaction of toxicants with organisms are described through paradigms in dose response, ADME, and toxico-/pharmacokinetics

Toxics in the 21st Century: Foundations of Toxicology

Figure 1. The Core Concepts of Undergraduate Toxicology. Core Concepts are the five emergent themes critical to undergraduate coursework in toxicology that emerged from analysis of diverse syllabi of undergraduate toxicology courses.


Model Organisms for Toxicology

- Describe the model systems
- Describe the evolution of the model systems
- Describe the role of evolutionary and genetic phenomena

Figure 2. Examples of 2nd, 3rd, and 4th level learning objectives for the Core Concept “Evolution”. Each of the five principle Core Concepts (1st level learning objectives) is broken down into three additional categories. The 2nd level defines a generic topic, in this example, “Model Organisms for Toxicology”. The 3rd level learning objectives define specific activities that the student should be able to perform upon finishing the course. Finally, the 4th level learning objectives provide specific concepts and case studies that inform the 3rd level. The 4th level objectives are meant to be comprehensive lists. The entire set of Learning Objectives is available at the hyperlink listed above. We invite commentary on the draft by 6/30/18.

SOT Continues to Add Resources for Undergraduate Educators:

- 15 Eminent Toxicologist lectures with associated learning materials
- Recorded professional development sessions targeted at undergraduate educators to assist in everything from teaching to professional development

Figure 3. The Vision & Change Core Concepts. The Vision & Change Report, published in 2011, provided the foundation for the development of Core Concepts for undergraduate Biology courses. V&C has since spread to other undergraduate courses which can be found at coursesource.org.

Figure 4. The format of the Toxicology Core Concepts was based on best practices aligned with Vision & Change. The Core Concepts of undergraduate introductory Biology “were organized around themes of inquiry in modern biology education. These concepts provide a set of overarching ideas. The overall goal of undergraduate education is to prepare students for the living world, and their use in teaching biology means to the multitude of facts that a student encounters in any undergraduate biology course.” Subsequent to the Vision & Change report, several academic societies have worked to develop Core Concepts for their own disciplines, each building upon the Core Concepts of the previous courses. These learning objectives are hosted at coursesource.org.

REFERENCES


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PROCESSES FOR THE DEVELOPMENT OF LEARNING OBJECTIVES

DRAFT DOCUMENT IS AVAILABLE NOW FOR PEER REVIEW


ANTICIPATED QUESTIONS

- What if my Toxicology course does not have Biochemistry and Molecular Biology or Anatomy and Physiology as a prerequisite? An educator might utilize the Biomedical and Molecular Biology framework available at coursesource.org to inform the teaching of their Toxicology course, adding material as necessary.
- Is this framework meant to cover every undergraduate Toxicology course? For example, what about Forensic Toxicology or Ecotoxicology? This framework was designed as the core for all undergraduate Toxicology courses, but an educator might emphasize some topics over others and add material depending on the nature of their course.
- Can I provide some feedback? Yes, please sign up to act as a peer reviewer. We will contact you shortly after the meeting with instructions for providing feedback.

www.surveymonkey.com/jf/7T8BZK3

For Peer Review


FOR PEER REVIEW


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