



## iCons I case study outline and approach

### **I. Outline for an iCons I case study**

It is intended that each case study used in iCons I will proceed sequentially through stages of inception – engagement – research – create – reflect. In some examples, these four stages may be accomplished by activities within one single class period. In others, activities and exercises may extend these stages over longer time.

#### **a. Inception**

This is the first stage in each case study. It involves introducing students to the topic, the issue, the problem, the underlying science. *Inception* may involve any/all of: articles, videos, animations, demonstrations, datasets.

#### **b. Engagement**

This is the stage where students become involved in the case study. *Engagement* may involve a discussion, initial report, debate, design, list, vote, etc. In *engagement*, students think about and begin to learn something about the topic, but should recognize that more information, research and/or understanding is required.

#### **c. Research**

This is the stage where students attempt to answer what has not been fully or adequately explored and understand during preceding stages. In *Research* students may design an experiment, critically evaluate data, formulate and address hypotheses, compile information to fill in knowledge gaps.

#### **d. Create**

This is the stage where students develop a new understanding based on what was learned through their research. In *Creation* a tangible product of the activity is created, such as a revised report, list, design, etc. Importantly, the knowledge gain during *creation* involves communication to the rest of the group or class.

#### **e. Reflect**

This is the stage where students reflect on the process they've been through. What focused and meta-skills did they use and develop? What did they learn that can be applied to future problems? What did they learn about their own interests and abilities?

### **Worksheet for Assembling a Case Study**

- 1. Pick the “Big Picture” Topic**
- 2. Assign the large-scale objective that reflects course’s Student Learning Goals**
- 3. Identify a small number (2-3) of goals that tie to specific skill sets**
- 4. Assemble the inception materials**
- 5. Assemble the create activities/products to identify what the students will “make” that accomplishes the specific goals in #3**
- 6. Assemble the engage questions that drive them towards the creation products**
- 7. Assemble the research materials, research questions, and research skills that allow them to create the product**
- 8. Dry run of the activities and exercises – actually answer the engagement questions, perform the research, generate the creation products**



## II. iCons I Exercises and Activities

The following list includes types of activities used in iCons I, grouped by broadly-defined scientific skillsets. The activities/exercises within each skillset emphasize fundamental scientific skills and practices, and generally increase in complexity, involvement and outcome; lower-numbered activities will precede higher-numbered activities during the course. In each case study, one or (usually) more of these are used. These activities are designed to fulfill the suite of learning goals for the course.

### a. Critical thinking

1. Critique: Critically evaluate an article, website, video about a science topic as presented in the popular media. Articulate and debate in groups the pros and cons of the article (website, video, etc.). Identify incomplete understanding, incomplete logic, incomplete information in the article (website, video, etc.)
2. Explainer: Develop a short written or oral report that fills in knowledge gaps identified in popular science media (articles, websites, videos, etc.)
3. Annotated bibliography: Create a bibliography (list of references and citations) that provides a brief summary of the content and usefulness of each reference. Summaries should be 100-200 words long, and include information about the content, purpose, bias, and (most importantly) strengths and weaknesses of the scientific argument in each reference.
4. Proposal: Create a written report proposing a potential new direction of scientific research or scientific solution to a societal challenge. A complete proposal will include: (i) sufficient background information on the social relevance, scientific basis, and prior related efforts by other researchers; (ii) clear articulation of the problem this new research will address, including identifying why the problem and your proposed solution are important to science and to society; (iii) a well-crafted scientific question and/or hypothesis statement; (iv) a research plan that included objectives, goals, tasks, and clear connections between goals, tasks and the overall project hypothesis or question; (v) expected outcomes of the project, describing how the research will be used in other future projects and why the effort is relevant, novel, useful and important; (vi) tangible products of the project, detailing the physical form(s) of the outcomes of the research that may include data sets, data analysis, a computational or analog model, a prototype, written or oral reports, etc.
5. Case study development: Develop a case study to employ in future iCons I courses. The complete case study will include materials and activities through class stages of inception, engagement, research and creation.

### b. Analytical reasoning

1. Formulate a scientific question: starting with initial curiosity about a scientific system or phenomenon, develop a question that relies on fundamental scientific principles or concepts to interpret that system or phenomenon. A well-crafted scientific question implies a specific hypothesis, and suggests specific measurements, observations, or data-collection that could be done to answer the question.
2. Demonstration – observation, interpretation, hypothesis design and validation: Beginning with observations (of a natural system, of a demonstration, of an experiment, of a data set), generate an interpretation of the cause(s) of the observation. This is followed by a hypothesis statement, and development of an analytical plan that will allow testing of the hypothesis through specific measurements, observations, models or data collection.

#### **c. Data analysis**

1. Correlation and association: evaluate data sets to establish relationships among variables. This will involve discussion of correlation versus causation, and should include both bi-variable and multi-variable analyses, as well as evaluation of principal components (i.e. correlated variables in multiple-variable data sets)
2. Observational and retrospective studies: establish which data are needed to address or answer a particular scientific question. In essence, determining what data to collect, observations to make, measurements to perform, in order to answer a question or to test a hypothesis. Following collection of data, observational and retrospective studies next pursue data analysis to determine if correlations (or more generally associations) exist. Retrospective and observational studies must also, when faced with large multi-variable datasets, disentangle which variables are relevant and which are irrelevant to the question at hand.

#### **d. Experiment design**

1. Analog model: develop a physical model or demonstration to experiment with processes and controls on a phenomenon.
2. Measurement-based controlled experiments: set up a formal, classical scientific experiment in which all (or at least many) external variables are controlled or set constant, and for which there is one independent variable that is varied and one dependent variable that is measured. Changes in the dependent variable are then correlated with changes in the independent variable.
3. Model/simulation based experiments: use computation or equations to make predictions about the behavior of a material at some new point in time and/or space given information and assumptions about initial conditions.



### III. Learning Goals – Topics – Activities matrix

Many of the activities described in II above are tied conceptually with one or more of the course learning objectives. Thus, a two- (or three-) dimensional matrix could be constructed connecting specific course topics with various learning goals.

iCons I learning goals:

- A. Critically evaluate the nature of certain societal challenges (access to clean water, energy demands, climate change, and disease and biomedicine), and explore possible scientific solutions to those problems.
- B. Discover scientific principles and concepts in the context of real world problems facing society.
- C. Work in diverse teams to collaboratively solve problems and develop leadership qualities.
- D. Develop appreciation of the interdisciplinary nature of the scientific process and scientific solutions to problems.
- E. Master the quantitative basis for evaluating the magnitudes and rates pertinent to societal challenges, and the quantitative assessment of cause-and-effect relationships in potential
- F. Quantitatively express magnitudes and rates associated with these challenges and solutions.
- G. Use and interpret primary data in formulating a scientific argument.
- H. Gain confidence in your ability to seek answers through direct observation and analytical reasoning.
- I. Use computer programming as a tool to analyze data sets.
- J. Understand the differences in experimental design, depending on the scientific question to be answered.
- K. Determine the validity and reliability of experimental data, and critically assess scientific statements based on that data.
- L. Learn about the technology and tools used to perform scientific investigations.

		iCons I topics:															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
iCons I learning goals:	A																
	B																
	C																
	D																
	E																
	F																
	G																
	H																
	I																
	J																
	K																
	L																

*place an "X" on the matrix where iCons I topics and learning goals coincide*