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| Stage 1 – Identify Desired Results (Goals and Enduring Understandings) |
| **Goals**What relevant goals will this design address (e.g., course objectives, learning outcomes)?**Course level****Content:** Students will be able to evaluate the potential hazards of a contaminant being introduced into a system, identify the reasons it is being introduced, and propose design alternatives at various stages in the process that reduce potential for harm, and evaluate the tradeoffs inherent in these alternative solutions.**Process:** Students will learn to work in a team on a design challenge, navigate the stages of this, balance workload and expectations, give group presentations, write individual and group reports and receive feedback on their writing |
| **Understandings:** * What are the big ideas students should understand?
* What are the enduring understandings that are based on the big ideas, and give content meaning & connect the facts & skills?
* What misunderstandings are predictable?
 | Students will understand …* That metals enter drinking water through natural and anthropogenic pathways
* That metals introduced by human activity arise as a result of humans meeting a resource need in some way
* That some metals in water are hazardous to human health and the environment, and that different environments and populations are disproportionately affected
* That technologies exist to remove many metals from drinking water but that these have associated costs (material, energy, financial) that may limit their applicability
* That it is better to prevent metal contamination of water at the source than to have to clean it up for drinking
* That designing upstream processes to meet our needs in different ways is a proactive, greener approach to environmental health

Predictable misunderstandings include…* Regulations and regulatory compliance provide adequate, medically and environmentally sound protection
* Cleanup interventions at the point source of pollution are the best-case scenario
* Industry should “just stop polluting”
* Water contaminants remain in the form through which they are initially introduced
* Conflation of hazard and risk
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| **Essential Questions:*** What provocative questions will foster inquiry to understand the big ideas and transfer learning?
 | Students construct meaning as they wrestle with the following questions…* Why are industrial processes releasing potentially hazardous metals into water that may be used for drinking?
* How can we intervene effectively the system to continue meeting the needs of all people without compromising the health and well-being of some populations and the environment?
* What does it mean to design a system that is inherently safer?
* Where is “away” when we remove waste?
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| **Knowledge & Skills:*** What key knowledge and skills will students acquire as a result of this unit?
* What should students eventually be able to do as a result of such knowledge and skills?
 | Students will know …* How to keep track of literature/database/online research findings using a query log
* How to evaluate credibility of an information source, and judge conflicting evidence
* How to search a series of databases for toxicology information
* How to identify intervention points in a resource use/pollution management process
* How to give compelling oral presentations
* How to present research and new ideas in an organized manner
* How to give and receive constructive feedback in the ideation phase of a design challenge

Students will be able to …*Aquatic chemistry and engineering:** Predict the introduction and speciation of metal contaminants in water based on an understanding of solubility, chemical and physical equlibria, redox chemistry, acid-base chemistry, buffers, photochemistry, and other environmental chemistry processes
* Describe the operation of several technologies for the removal of contaminants from drinking water using the principles described in the previous point (electrochemical, membrane, adsorption, precipitation)
* Predict how effective a technology will be for removing a particular contaminant based on these principles

*Hazard and Risk:** Understand the difference between hazard and risk, and the legal implication of “risk assessment” (R = f(h,e,v))
* Describe major categories of human and environmental toxicological hazard
* Describe, at an introductory level, by what chemical processes Hg, Pb, Cr, Cd and a few other metals are active toxicants
* Qualitatively identify relevant exposure pathways for metals in drinking water
* Describe the possible interactions of contaminants in a complex system (synergy, antagonism, changes in bioavailability)
* Understand vulnerability as a summation of situational factors

*Industry and Regulation:** Describe, for a particular metal, its major anthropogenic pathways to entry into drinking water sources, including where geographically it is a concern
* Explain in chemical terms the purpose of the metal in the process or product from which it is released.
* Quantify the significance of the process to which the metal contributes in the local and global economy (i.e. why is it important? Who benefits?)
* Compare regulations surrounding metal release and evaluate how these regulations might foster or stifle innovation

*Life Cycle Thinking and Design** Overview the process by which water comes to be drinking water in urban and rural settings in Canada and a developing country relevant to the metal studied
* Identify the possible points for intervention in an existing process that would reduce human drinking exposure to water
* Identify the actors, incentives, and barriers to change at each stage
* Based on literature and synthesized understanding, propose an intervention at three different stages, identifying the benefits, drawbacks, potential health/environmental hazards, uncertainties, data gaps of each proposed intervention

*Process** Write and present ideas in a clear and concise way
* Keep track of research using a query log
* Use diverse information sources, and evaluate their credibility
* Work as a member of a team, distribute workload and tasks
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| Stage 2 – Assessment Evidence |
| **Assessment Tasks:*** Through what tasks, which offer multiple opportunities to explain, interpret and apply their thinking, will students demonstrate their understandings? (e.g., quizzes, discussions, tests, observations, homework, journals)?
* By what criteria will understanding be judged?
* How will students reflect upon and self-assess their understanding?
 | Students demonstrate their understanding with the following tasks…* Final Group Report on the assigned/chosen metal, written as an engineering consulting deliverable to an engineering firm which
	+ Describes the aquatic chemistry, toxicology, regulation, industrial use/discharge
	+ Outlines the existing material flow
	+ Proposes interventions with a focus on green design and discusses their opportunities and limitations
* Final Presentation of the report to the class
* Interim deliverables:
	+ Oral presentation and individual(/group?)-led facilitated brainstorm on proposed interventions
	+ Industrial flow process chart (work with Dave on what this looks like) and written one-page summary
	+ 1-2 page summary of relevant regulations of discharge of the metal in US/Canada, EU, Asia/Africa (as relevant) and regulations for drinking water in the same region. References fully cited from original source (i.e. actual reg, not just a website that summarizes the reg).
		- Submit query log for review
	+ 1 page description of chemical process the metal facilitates in selected industry, with chemical equations, process diagrams as appropriate
		- Short presentation
		- Brief market size estimation in selected industry (what would it cost if we stopped using this metal tomorrow)
	+ 1 page discussion of human and environmental health hazards, with discussion of routes of exposure and vulnerabilities
		- Submit query log for review
	+ Individual assignment: 1-2 page (with chemical equations) description of entry and speciation of metal in the environment, giving a run-down of impacts of: reducing environments, oxidizing environments, biotransformations, phototransformations; evaluation of appropriateness of existing technologies for removal down to safe drinking water levels
	+ 1 page consulting-style scope of work outlining deliverables
* Quiz/exam on chemistry content – buffers, equilibria, speciation – comes at the end of the initial chemistry lectures

Students self-assess their understanding through the following tasks…* Possible chemistry skills self-assessment multiple choice from a past Chem 150 final/Caetano’s final from a different year?
* Toxicology online unit has self-evaluation
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| Stage 3 – Learning Plan & Activities |
| **Learning Activities:**What learning experiences and instruction will enable students to achieve the desired results? Mixture of traditional classroom instruction and project-based learning. Core content material from chemistry will be taught in a traditional manner, toxicology will be a mixture of NIH ToxTutor and classroom, and other direct teaching will be process-based skills. Guided discovery will be used in most process-based learning, with tools or databases introduced and then used immediately in class and bring back to check group understanding |
| * How will students know where the unit is going and what is expected?
* How will instruction and tasks activate and connect students’ prior knowledge?
* How will instruction and tasks engage students & sustain their interest?
* How will instruction and tasks encourage students to experience and explore the big ideas and enduring understandings?
* How will instruction and tasks offer students the opportunities to think about and discuss ideas with peers, and others more knowledgeable?
* How will instruction and tasks allow students to reflect on, evaluate, and revise their work?
* How will instruction and tasks be inclusive to the different needs, motivations/expectations, attitudes/beliefs, and abilities of learners?
 | * Course outline will give clear plan for each day and for arc of when assignments are due
* Course outline will also provide learning objectives for each unit
* Assignments will be posted in advance with detailed expectations and opportunities for feedback
* Initial chemistry content will be connected to prior knowledge through self-assessment. Kinetics will link to toxicology. Relevant practical knowledge is currently an unknown.
* After initial core content homework and toxicology online course, all assignments will directly serve to feed the final product, so doing well early will reduce later workload
* Major deliverable is design of three interventions
* Early stage instruction will explicitly include a session on teambuilding, group dynamics, setting goals together, etc.
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