EDU236X BEYOND BITS AND ATOMS
CSSI : CONSTRUCTING SCIENCE FOR SOCIAL IMPACT
CURRICULUM RESOURCE

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I. OVERVIEW OF THIS RESOURCE

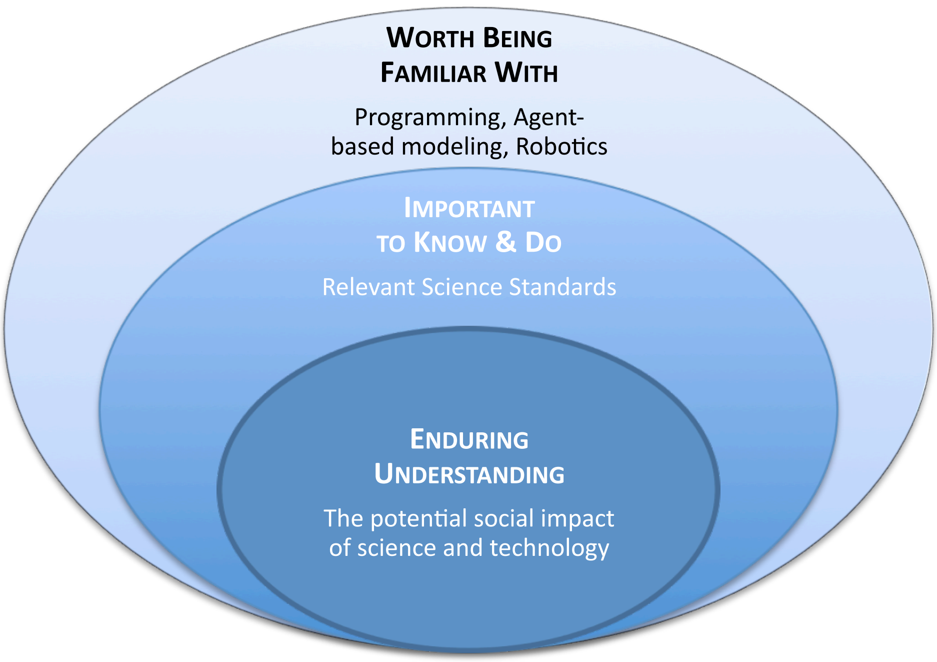
This is a curriculum resource document for teachers who are implementing the CSSI (Constructing Science for Social Impact) curriculum. CSSI is a constructionist-social-constructivist curriculum for the teaching of science. Students will be challenged with real-world problems, and will design solutions and models with which to understand the impact and role of science and technology. The curriculum will also be aligned with some of the Californian Science Standards. This curriculum resource will present an overall framework for implementation, and will describe in detail one physics module.

II. TARGETED LEARNING CONTEXT

The proposed curriculum is targeted at high school students, Grades 11 – 12. It is assumed that these students are familiar with the basics of Netlogo programming, robotics and the use of various technology tools.

III. LEARNING GOALS

Wiggins and McTighe's "Backwards Design" model (1998) is used to design this curriculum. At the heart of the curriculum is the the Enduring Understanding, which is the big idea that students will take away from the curriculum. This is then extended to What is Important to Know and Do, and finally What is Worth Being Familiar With. This is illustrated in the diagram below :



1. **Enduring Understanding**
   The core goal of the curriculum is that students will be able to see the social impact of science and technology. In engaging the students in the design and construction of solutions to real-world problems, students will be able to appreciate the complexities involved, and to understand the potential social impact and applications of scientific concepts and principles.

2. **Important to Know and Do**
   The next tier of curriculum goals are in alignment with science standards, taken from the Science Content Standards for California Public Schools, Kindergarten through Grade Twelve, adopted by the California State Board of Education in 1998.[1] The example used in this resource is aligned to the following science standards, found in the section for Grades Nine to Twelve :

   Heat and Thermodynamics
   Energy cannot be created or destroyed, although in many processes energy is transferred to the environment as heat. As a basis for understanding this concept :
   - *Students know* heat flow and work are two forms of energy transfer between systems.
   - *Students know* that the work done by a heat engine that is working in a cycle is the difference between the heat flow into the engine at high temperature and the heat flow out at a lower temperature (first law of thermodynamics) and that this is an example of the law of conservation of energy.
   - *Students know* the internal energy of an object includes the energy of random motion of the object's atoms and molecules, often referred to as *thermal energy.* The greater the temperature of the object, the greater the energy of motion of the atoms and molecules that make up the object.
   - *Students know* how to solve problems involving heat flow, work, and efficiency in a heat

   Electric and Magnetic Phenomena (more on the Electric Phenomena)
   Electric and magnetic phenomena are related and have many practical applications. As a basis for understanding this concept:
   - *Students know* how to predict the voltage or current in simple direct current (DC) electric circuits constructed from batteries, wires, resistors, and capacitors.
   - *Students know* how to solve problems involving Ohm's law.
   - *Students know* any resistive element in a DC circuit dissipates energy, which heats the resistor.
   - Students can calculate the power (rate of energy dissipation) in any resistive circuit element by using the formula Power = IR (potential difference) × I (current) = I^2R.
   - *Students know* the properties of transistors and the role of transistors in electric circuits.

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[1] www.cde.ca.gov/BE/ST/SS/documents/sciencestnd.pdf

Energy in the Earth System

Energy enters the Earth system primarily as solar radiation and eventually escapes as heat. As a basis for understanding this concept:

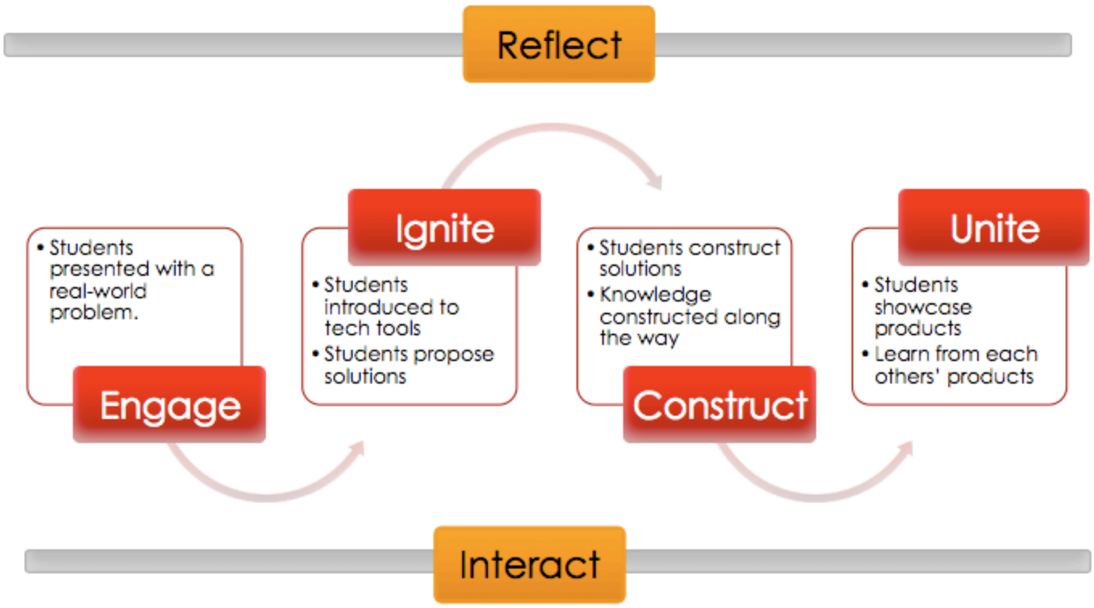
- *Students know* the relative amount of incoming solar energy compared with Earth's internal energy and the energy used by society.
- *Students know* the fate of incoming solar radiation in terms of reflection, absorption, and photosynthesis.
- *Students know* the different atmospheric gases that absorb the Earth's thermal radiation and the mechanism and significance of the greenhouse effect.

3. Worth Being Familiar With

It is not the primary goal of this curriculum for students to acquire skills of programming, agent-based modeling using Netlogo and robotics. However, programming and agent-based modeling can facilitate development of thinking skills and logic. Agent-based modeling and robotics may also facilitate the understanding of the various scientific concepts listed above. Hence, although not the primary focus of the curriculum, these aspects are worth being familiar with.

IV. DESCRIPTION OF ACTIVITIES

The framework for activities within the curriculum is presented in the diagram below :



1. **Engage**

   Real-world problems will be framed in the context of the United Nations Millennium Development Goals[2], which include : (1) End poverty and hunger; (2) Environmental Sustainability and (3) Global Partnership.

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[2] http://www.un.org/millenniumgoals/

There is a large number of non-profit organizations which have utilized scientific principles to devise creative inventions and solutions to problems in the least developed countries in the world. Some of these organizations were featured as finalists in the 2008 Tech Awards[3], and may be used to engage students. These include :

- FullBelly.org (http://www.thefullbellyproject.org/)
- Desipower (http://www.desipower.com/how/how_main.htm)
- The Portable Light Project (http://www.portablelight.org/)

Each of these organizations has implemented science- and technology-based solutions in developing countries to solve problems of hunger, poverty and climate change. For example, the solutions include sustainable harnessing of solar power to provide power for other uses.

Students are issued with a challenge of engagement to :

- Design and implement an experiment to answer questions on how the technology works.
- Construct a prototype of the technology solution
- Create a simulation of how the technology solution works, using Netlogo, with robotics and model the social impact of the technology.

2. Ignite

Having been engaged with the real world problems and what people have done to address these problems, and having been issued with the challenge of engagement, students are subsequently introduced to the technology tools :

- Netlogo
- Gogoboard, robotics & sensors
- Other technology tools like the 3D printer and laser cutter

Working in groups of 3, students brainstorm on what they want to do, working with any of the technological tools. This stage is meant to ignite the students' imaginations, get them excited about the project, and to let them begin to see the potential social impact of science and technology, while recognizing and discussing the potential constraints present.

3. Construct

Students then begin to construct their solutions. In the process, there are definite content knowledge and skills that they need to acquire. These are aligned with the learning goals stated above. The tools are designed to be the 'gears' with which students construct their knowledge – the 'transitional objects' that can form a conceptual bridge for these students. (Eisenberg, 2007) In creating a simulation of how the solar power technology works, students need to construct knowledge about energy, power and how one form of energy is converted to another. In modeling the social impact of the technology, they need

[3] http://www.techawards.org/laureates/

to understand other power needs of the community, and think about electricity and heat loss principles. In order to propose a sustainable funding model, they need to consider the energy efficiency of the entire system, and how that factors into the immediate context of the community.

4. **Unite**
Students subsequently come together to showcase their products, and to learn from each others' products. The beauty of a constructionist approach to learning is that it is open-ended enough for different students to pursue different learning paths. This stage is designed to unite the knowledge constructed by the whole class as there is value in building on each others' constructed knowledge.

5. **Interact**
Processes for interaction are built in to the <u>entire</u> learning process. There are two dimensions of interactions : between students in the group and between students and the teacher-facilitator. This is designed to facilitate the social dimension of knowledge construction. The role of social processes as a mechanism for learning is traditionally associated with Vygotsky, who suggested that "the social dimension of consciousness is primary in time and in fact. The individual dimension of consciousness is derivative and secondary." (Vygotsky, 1978) This implies that the cognitive functioning of the individual is not simply derived from social interaction; rather, the specific structures and processes revealed by individuals can be traced to their interactions with others – there is a dimension of interdependence between individual and social processes in learning and development. Hence, this curriculum is implemented with an emphasis on providing a platform for social interactions.

6. **Reflect**
Reflection is also built in to the entire learning process. Students' reflections are scaffolded at various stages to facilitate development of metacognitive skills. Flavell (1976) characterized metacognition as "one's knowledge concerning one's own cognitive processes or anything related to them, e.g. the learning-relevant properties of information or data. … Metacognition refers, among other things, to the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects or data on which they bear, usually in the service of some concrete [problem solving] goal or objective." (1976, p232) Metacognition refers to the cognitive processes of self-regulation when one engages in problem-solving activities.

Various stages of the curriculum will be scaffolded in the following ways :
- Engage : students to reflect on social impact and the role of science
- Ignite : students to reflect on what they need to learn to construct the solution
- Construct : students to reflect on what they are learning and constructing
- Unite : students to reflect on the work of the other students and how that adds to what they know

V. RATIONALE FOR TECHNOLOGY USE

This curriculum is designed to direct students' learning efforts towards appreciating the social impact of science and technology, while at the same time constructing knowledge around topics aligned with science standards. The technology tools are meant to serve as 'gears' with which students can think, engage and grow. Netlogo and agent-based modeling is particularly suited to be used in this context. It is open-ended enough to allow students to explore any route of knowledge construction, and is yet directed enough to ensure students think through fundamentals. The appropriateness of Netlogo for these purposes is clearly articulated by Wilensky and Resnick (1999),

"In our view, the very question of "objectness" becomes a question of "levels." Objects that are viewed as singular at one level are best viewed as plural at another level. The ability to shift levels, viewing the same object as either singular or plural, depending on the situation, is a prerequisite for building deep, scientific understandings of phenomena."

Netlogo engages students in the thinking of laws and rules governing behavior of individual agents – these may be from electrons/power to light particles/solar power and portable light/social impact.

Robotics and sensor-based input-output devices are appropriate in this curriculum as they can be tools with which students can understand concepts of electricity, power and heat. As students work with sensors that detect heat, light etc, they are driven to seek to understand how they work, thereby also learning the relevant scientific concepts and principles. Other technologies for construction like the 3D printer, laser cutter, vinyl cutter etc should also be made available to students. This is to facilitate learning for some students who may prefer to work with tangible artifacts.

Finally, web 2.0 tools will be used as platforms for asynchronous and synchronous interaction and reflection.

VI. THE PORTABLE LIGHT PROJECT : A SAMPLE MODULE PLAN

Week	Learning Activity	Resources for Teachers	Remarks

1	**ENGAGE**
	• Introduce students to the Portable Light Project
	• Issue to students the challenge for the module :
	  o Experiment
	  o Prototype
	  o Simulate
		Powerpoint slides
		Portable Light Project video
		CSSI Website : http://cssi.weebly.com
			NOTE TO TEACHER : *This part of the module is meant to whet the students appetite for the concepts (listed above as part of the*

	• Introduce the various technology tools available in the lab.		*Science Standards)*
	IGNITE • Organize students into groups of 3. • Each group is to brainstorm ideas for the experiment, prototype and Netlogo model. • Each group is to draft a proposed plan of action by the end of the week.		NOTE TO TEACHER : *Work with each group and asking guiding questions. Some examples of questions are on the CSSI website, along with sample prototypes.*
2	**IGNITE** (*Continued*) • Laboratory session to allow students hands-on experience with technology tools.	Laboratory equipment: • Laser cutter • 3D printer • GogoBoard & sensors • Associated tools	NOTE TO TEACHER : *The students should already have mapped out general plans for their experiments and prototypes. They should raise questions during this lab session regarding feasibility.*
3	**CONSTRUCT** • Students work on their projects. • The teacher's role is that of a facilitator, working alongside the students, asking prompting questions, and addressing any questions the students may have. • They interact on the CSSI website.	CSSI Website : http://cssi.weebly.com	NOTE TO TEACHER : *Encourage students to interact on the CSSI website, asking questions, attempting to answer each others' questions, and writing personal reflections*
4	**CONSTRUCT** (*Continued*) • Students continue to work on their projects. • One special face-to-face Q&A session to address issues and questions students may raise.	CSSI Website : http://cssi.weebly.com	NOTE TO TEACHER : *Do not lecture or teach concepts. Ask students to submit questions they may have, and organize the answers to align with topics in the standards.*
5	**UNITE** • Students showcase their experiments, prototypes and simulations via a 10-minute presentation and demonstration. • Students learn from each other's products.		

VII. REFERENCES

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