Environmental Research:

Student Driven Research Into Green Technology

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Grade Level – High School

Overview

Students are assigned the task of researching green technologies after viewing a video that described the need for alternative energy sources and types of technology available. The students assigned this project are students who volunteered for a pilot program at a public high school that will require them to ultimately complete large research projects of their choosing, but the lesson is applicable and relevant to all high school students. The ultimate goal is to give the students an opportunity to use the library and research systems available to them. A secondary goal was to teach them about greenhouse gases and ways to reduce the environmental impact of humans on the planet. Students are to perform research on randomly assigned technologies and create some presentation showing that they learned a great deal about the technology. Students then develop a tri-fold brochure to share what they learned with their classmates. Due to limited library access and technology there may be limits to the project. Use of this lesson is dependent on making library time and computers available to the students. This lesson is recommended to all science educators that have good library and computer lab access, especially in the newer schools that have dedicated these types of resources to current and relevant scientific studies such as global climate change.

Concept

The lesson addresses the concepts of literary review prior to experimentation, greenhouse gases, global warming and green technology. Effective communication, debate skills and coherent, cognitive presenting are secondary concepts for the student teams.

Nevada State Standards

The standards addressed are:

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- N.12.A.1 Students know tables, charts, illustrations and graphs can be used in making arguments and claims in oral and written presentations. E/S
- N.12.B.1 Students know science, technology, and society influenced one another in both positive and negative ways. E/S
- N.12.B.2 Students know consumption patterns, conservation efforts, and cultural or social practices in countries have varying environmental impacts. E/S
- E.12.A.1 Students know the Sun is the major source of Earth's energy, and provides the energy driving Earth's weather and climate. E/S
- E.12.A.3 Students understand the role of the atmosphere in Earth's greenhouse effect. E/S
- E.12.A.4 Students know convection and radiation play important roles in moving heat energy in the Earth system. E/S
- P.12.C.2 Students know energy forms can be converted. E/S
- P.12.C.5 Students know the relationship between heat and temperature. I/S
- P.12.C.6 Students know electricity is transferred from generating sources for consumption and practical uses. I/S
- L.12.C.3 Students know the amount of living matter an environment can support is limited by the availability of matter, energy, and the ability of the ecosystem to recycle materials. E/S

Basic Procedure

As an engagement activity students are shown a film by Peter Byck (2011), Carbon Nation (USA) Clayway Media. The film discusses the nature and science behind greenhouse gases and some of the technology and techniques to reducing emissions. It takes up to three days to watch the film during which time topic discussions from the film are addressed and student questions are answered. After the film student teams pull a stick from a jar. Each stick will have a different type of green technology that be required to research. The possible topics are the major alternative energy types: photovoltaic power, solar thermal, absorption refrigeration, siting – passive solar, wind power, hydroelectric power, geothermal power, biomass, renewable/green

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materials, grey water systems, geothermal hot water system, solar water heater, and fuel cell. With the assigned topics students are to visit the library and get a day with the school librarian to learn about library research options and databases available to them.

The students working in teams of two or three research their topic and learn all that they can about their chosen renewable energy area. At the beginning of each class progress, problems, and ways to identify valid information versus junk are discussed by all student teams in the classroom setting. After a week students are told they are charged with putting together a brochure on their technology and are given a rubric for the grading of the project.

This may cause the students to change how they researched and what they were searching for. They will then begin planning how to employ their technology and start to figure out how to question other competing technologies. They are placed directly in competition with other students for domination of the green energy market. Student teams will then take their information and begin planning a strategy to find flaws or shortcomings in the other student topics to make theirs look better. Students are then given an additional week to put this together with the new directive that class time will be limited and the bulk of the remaining research must be done on their own (homework) time. Time in class should still be devoted daily to dealing with questions and problems.

Student teams do class presentations of their technologies allowing students to question each other and attempt to stump the presenter. Copies of each brochure should be made available to all students for these discussions. This activity as a kind of formal research project ties in directly with other school research projects and can be made into a cross-curricular project with

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the cooperation of instructors in other departments. The only input from the instructor should be helping students determine if a source was of good quality and periodic reminders that their

classmates are also researching their topic on the side in order to get bonus points or some other "prize" for having the best green company brochure.

Green Energy and the Nature of Science

The nature of science standards perhaps play the largest role in the assignment since students are required to review a large number of articles and journals containing a number of graphs and data sets that they have to interpret. Students are also charged with finding other sources in conflict and find a way to resolve or dispute the conflict to support their idea or previous statement. The concept of the Nature of Science lends itself especially to discussing the scientific method because some sources are not very valid or strong. You may assign extra credit for any team that can dissect and discuss how one or two sources of scientific "findings" are not valid or have weak science in their arguments.

The student teams must be able to identify and eliminate scientific method elements or be prepared to defend using them. During class introduction sessions instructors need to address the inevitable situations where student teams find something they really want to use, but know it was a weak source. In most cases they bring it up to test their arguments. Allow the other students the chance to debate it out for them and by the last few days it will turn out that most often the students that ended up working out the resolution on whether or not the data was sound will be

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the ones with the strongest projects. They will become very aware of how internet data can be biased and invalid! The project itself forces them to be aware of science standard N.12.B.2 and the efforts humans make to conserve resources and the environmental impacts of our existence.

Differentiated Instruction and Grading Rubrics

In most school systems the students come from a variety of backgrounds and this leads to them being at many different levels. This large gap makes differentiated instruction critical. Being aware of the varying student ability levels in a single class is important when talking with them when they ask questions because the expectation had to vary as well. The use of the rubric and the students having it in advance helps immensely because stronger students that would include all of the information as they do the project by nature, but the weaker students need the guide and structure. The grading should be standardized by the rubric while the comments and discussion vary depending on the student. Frequent check-ins with students made possible more direct oversight and significant help to the project. In doing so and working with students at the level they are at, will allow the instructor to gauge which teams need more one-on-one time and which teams are self-directing and pushing each other to produce more.

Every student was addressed at least twice a week in a one on one talk and the class as a whole spoke to each other every Friday. This informal assessment let students get feedback and ideas as they were working. The presentation allowed them to see how other students took what they were saying and to answer questions from peers. The presentation allowed the instructor to see how confident the student was in their knowledge and ask questions about their understanding of the science/technology while the brochure provided the chance to show language skills as well as student understanding given time to reflect and revise. The project lends itself to many grades if your goal is to get grades on paper, but it is much better at allowing the instructor to see the whole student.

Additional Research Considerations

Each student team is free to pursue their research and present what they feel comfortable with. When the students start the project, the first few days will see that not all are on task at the

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library and some will not be really working to their potential. What is most effective in getting all the groups on track and enthusiastic will be the daily and weekly check-ins and discussions. The one very motivated focused student who is pushing hard gets the others to realize they had to step up and start to focus and work harder.

Each project should be assessed informally by daily or weekly status checks that include the required five sources after a week in the library as well as the final brochures. The sources required to provide evidence of research and not just free time in the library. Team leaders are told they need to not only have the citation, but also what was the source being used for to avoid them simply finding five random citations. The recommendation to put the citations on index cards so they can be modified new sources added and others removed as they worked through the project provides a double check on student accountability.

Encourage hand-written citations so that the student is staying free of the rubric and truly researching the topic to learn all they can and not narrowing their view. The other students could be limiting themselves to just the rubric and not stretching themselves. So keep on the lookout for this. In science going beyond the obvious in key and this is not present in those two citations. Some student teams will stick precisely to the rubric exactly and only do the bare minimum. This should make two conclusions clear, first the rubric helps with students understanding the project but they tend to limit themselves with it, and that they chose a topic that they were not entirely passionate about.

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Teacher Personal Notes and Comments

This project was very unique for me as a teacher because my initial idea had to evolve as the class developed. The students for this class were recruited from other classes. The time frame was in our pass classes which is 45 minutes first thing in the morning four days a week. These students started out in other classes and where given the option to join the class. None of the other classes require assignments and homework so they were volunteering to do more work for the right to pursue an educational path of their choosing.

The initial video was not structured enough so including a guided worksheet with it to hold better focus and draw attention to big ideas was way to get around that. The research topics started out well and the students were excited because many of them had little to no background knowledge of what they were studying. This made for some excitement however the power of the distraction on the internet and in the library led to some issues as the age group is 15 - 17. I didn't want to add more structure, but in the future I will add more check points. I think including a journal for them to write in each week reflecting what they have learned so they have a check point and bar to get over would really help the off task behavior, because even though they needed to complete a brochure they put it off. With the citations some students really didn't find anything until the day before they were due. The freedom given and the open ended aspect of the original task was good and bad, because it really made the students start to analyze themselves as learners, while the freedom also set some up for failure and procrastination.

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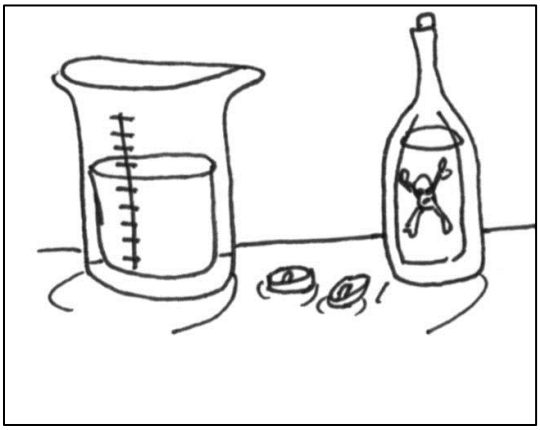
The chance to move around and talk to students instead of talking to the class and getting to address each student as an individual is an important part of the teacher role in this project. Helping them as opposed to trying to teach the whole class, while some students are involved and others stuck waiting makes a big difference in student motivation as well. This really opens the opportunity to free them to learn at their own level. Instead of the doing a typical book lab that has a required write up and report, following a set procedure to force students to complete predetermined tasks in order to see set outcomes, they had a freer, more inquiry-based experience more in line with the overarching concept of the nature of science.

In this part the goal was for students to get to visualize a single replacement reaction as well as a non-reaction. Typically we accomplish this by have students place a nail in copper (II) sulfate and then prompt them to observe the color change on the nail and the color change of the solution we further go on to have them place copper wire into iron (II) sulfate and repeat the same process. Every step and measurement is done for them so they simply fill in the blanks while following the cookbook. This time they were told to get a penny that is post 1982 so it contains zinc and copper. They were given acid and told they could not use more than 50 mL. They had to observe the penny and somehow make a nick in the copper coat so they could see the zinc. They then were told to observe what happens in the acid and after. The first group used all 50 mL of acid and had everyone come look because the penny was bubbling at the nick. Immediately other groups started making a lot of nicks because they wanted more bubbles and others tried less acid to see if it made less bubbles. This proceeded until all of the students had their pennies in and were moving around to see who made the most bubbles. One group had no bubbles and the classes decided they forgot to nick the penny. The students in the group swore they did, so a group of five students really started looking and a kid noticed the penny was from 1976. They asked what that meant so I had the entire class look at a 1980 penny that I cut a large nick in and they realized there was no zinc and immediately a student said the bubbles are



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coming from the zinc.

While the pennies sat I had a student write the reaction for zinc and hydrochloric acid on the board. The class corrected it a few times to get the right reaction and a girl pointed out the hydrogen gas as a product meaning the bubbles have to be hydrogen. Another student asked why the copper penny didn't bubble. We wrote the equation for copper and hydrochloric acid and it appeared we should see bubbles and a student pointed out that copper must not react and a second student recalled the activity series and they soon realized what "no reaction" means. I did the activity because without set instructions there are very few critical questions to ask. Consequently I was free to move around and talk to students asking questions based on what they did and sending them to look at what other students did where a different approach helped. I feel not having to be so structured lets the students really interact with material. There was no formal assessment for the lab other than the discussion and seeing students excited and knowing that they had approached true nature of science, scientific inquiry.

Assessment

Student discussion during presentations can very profuse as they try to find flaws with the other teams' research and technology to promote their own. The ability to effectively argue both sides is an excellent skill to learn and forces students to think about the topic they researched beyond the simple facts they find for their research. Additional ways to assess student learning should include informal assessment techniques daily as the projects are being developed. These should include but are not limited to:

- Using oral questions after research periods.
- Student teams are required to turn a daily status report that contains observations, diagrams and answers to questions at the end of each period.
- Building upon the questions they were already asked is a good technique to drive home points and informally assess what they learned. Review of these at the end of class is very effective as well.

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- Incorporating journaling as a way of thought organization, individual student reflections, and team project ideas is an excellent method of getting to see what they are learning and planning.
- In the second phase of the project research use needs demonstrated by student teams to design short but relevant activities on green energy and climate change science that will spur the groups to push themselves beyond the question they ask to the answers they seek.

Naturally the graded brochures and presentations based on the clear and explained rubrics (for each) will round out the assessment process.

Please share your comments about successes with this method with Eric McCuskey, c/o North Valleys High School, 1470 E Golden Valley Road, Reno, Nevada 89506, 775-677-5499 or by e-mail: Eric McCuskey<emccuskey@washoeschools.net>

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