The Driving Question

How small is too small when designing the next BIG thing?

Focus on Teacher

Detailed description of content and learners:

This unit is being designed for a Geometry class containing approximately 30 freshmen to sophomore students. The students in this class represent a mix of social-economically diverse boys and girls in a suburban setting.

Description of the driving question including a detailed explanation of how the driving question is ill-structured, authentic, meaningful, interdisciplinary, and appropriate:

<u>Ill-Structured:</u> This question uses many vague terms, such as “too small” and “next big thing” for the purpose of leaving it up to interpretation by the students. This will allow students to determine on their own what they feel “too small” means. For example, students may use it as the literal meaning of having a mobile device too small for practical use, or students may interpret it as an opportunity to explore any drawbacks to using small components within a device. We also used the phrasing “next big thing” because it will allow students the freedom to use their own individual passions to forge their vision of the next landmark technology.

<u>Authentic and Meaningful:</u> This question links the students’ interests in the hottest technology and allows them to investigate their passion with an outcome that has the potential to impact the future. The students will make a sales pitch to a panel of potential investors for their “next big thing” which will provide a platform to impart meaning to their work.

<u>Interdisciplinary:</u> This project incorporates key components of several different disciplines. While progressing through this project, students will encounter topics in nanotechnology. They will experience science principles and how material properties change at the nanoscale. Students will also investigate marketing principles as related to product design. While working on this portion, students will also have the opportunity to explore sampling and data collection. This provides a segue into the mathematics content, which will be the main focus.

<u>Appropriate:</u> This unit is appropriate for the demographic of students selected, because it focuses on the related content standards while promoting a real context that is authentic for the students.

Detailed description of how the driving question relates to the curriculum and specific examples of how you will keep the students focused on the question.

Given the nature of this project, many different mathematics content standards can be met. The complete list of the standards we have identified are [linked here on the standards page]

Some of the most influential standards in this unit include:

G.QP.5: Quadrilaterals and Other Polygons
Deduce formulas relating lengths and sides, perimeters, and areas of regular polygons. Understand how limiting cases of such formulas lead to expressions for the circumference and the area of a circle.

- If students are investigating nanotechnology and its effects on the size of technological devices, they will be required to learn how to relate lengths, sides, perimeters, etc. to address this content standard.

G.TS.5: Three-Dimensional Solids
Solve real-world and other mathematical problems involving volume and surface area of prisms, cylinders, cones, spheres, and pyramids, including problems that involve algebraic expressions.

- Nanotechnology affords the opportunity for our students to deal with real work problems involving surface area to volume ratios that will be addressed in finding the volume and surface area of three-dimensional solids.

PS.4: Model with mathematics.
Mathematically proficient students apply the mathematics they know to solve problems arising in everyday life, society, and the workplace using a variety of appropriate strategies. They create and use a variety of representations to solve problems and to organize and communicate mathematical ideas. Mathematically proficient students apply what they know and are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.

- While progressing towards an answer to the driving question and designing a device, the students will be using their mathematical skills to model the real-life scenario in which the devices we are accustomed to are developed. They will be required to communicate their ideas and evaluate the ideas of their peers. To do this, they will likely use diagrams, graphs, and flowcharts to represent their thinking.

This driving question allows students the opportunity to assert personal choice in the types of technology they choose to investigate. This will be motivating for the students to choose items that correlate with their own passions. The driving question can also be posted in the classroom area and on each document the students are using throughout the unit to help ensure that it remains at the front of their mind. When they begin to stray from the driving question, the facilitator can redirect their attention back to the appropriate task by asking the students prompting questions such as:

- Have you considered how you will pitch your idea to the investors?

- How is nanotechnology interacting with the design you have created?
- What concerns do you expect the investors to have regarding your plan?

Focus on the Students

Description of examples of how the question is open-ended, allowing for different investigative questions (provide samples questions students might explore)

The wording of our question gives it an open-ended component which allows students to explore various concepts:

- Cost/Benefit analysis of implementing nanotechnology in mobile devices
- Property changes as components get smaller
- Manufacturing methods and processes of the components
- Impact on functionality as consumer products get smaller
- Marketing analysis of consumer interest and value

Focus on the Content

Detailed description, with examples, of how the unit is focused on nanoscience.

- Students will consider how small is too small in technology. This will allow them to relate the size of a nano-sized object to objects they encountered everyday. For example, why has the cell phone gone from the size of a book to the size of the palm of your hand?
- Students will need to deal with units when moving from smaller dimensions to larger dimensions. This will allow them to be able to apply dimensional analysis in conversion problems. For example, using the "Nanometer Activity" project to allow the students to take an everyday item and see what it would be like to go from the nanoscale to the macroscale.
- Students will be learning about surface area and volume. Our unit on nanotechnology will afford them the opportunity to see why the surface area-volume ratios play a role in objects at the nanoscale.
- Students will construct arguments and give examples in our PBL of why their nanotechnology is the best. They will need to explain why properties of matter change at the nanoscale to give evidence behind why their piece of technology works.

Detailed description, with examples, of how the unit is grounded in real life and work beyond school.

The project will encourage the development of 21st century skills through investigating, collaborating, evaluating, and presenting their team's project. The skills that will be exercised include:

- Thinking creatively to develop their product and their presentation.
- Making decisions through selecting item to design and determining key characteristics to consider.
- Solving problems will be addressed as students are dealing with the positive and negative limitations involved with nanotechnology.

- Self-Directed because students will work on their own developing their individual piece of technology to present to the class.
- Iterating will continuously happen as students are improving their product based upon the comments and suggestions from their peers, in the form of a gallery walk, for example.
- Collaboration (leadership and communication) will occur throughout the entire unit as students work together to brainstorm, create, and present their innovative product.
- Justifying and persuading will happen towards the end as students present their finished projects to the class and try to get their technology adopted.

Focus on Process

Explicit application of course materials and presentations are visible and appropriate.

As this unit was developed, we have pulled from the pool of resources and example activities. We have chosen to incorporate an activity like the “Nanometer Activity” to introduce the concept of dimensional analysis.

As the topic of nanoscience is introduced, we can also use the KWL chart process to brainstorm and gather the information the students know and identify the areas they need to research. This can be updated as the students work through the unit.

Based on the gallery walk we experienced, we have chosen to incorporate a gallery walk activity for students. After students have started to formulate the vision for their device, we can use the gallery walk to allow students to gain a new perspective and fresh avenues for investigation for their own devices.

Prensky (2010) was very influential in helping us develop our driving question. We strived to make our driving question relevant, address our standards (math and nano), and be ill-phrased and vague enough to allow for multiple solutions.