CAPSULE: Capstone School-Based Implementation Plan

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OVERVIEW OF PLAN

Currently, I teach a physics course that is loosely based on the Modeling Instruction approach to physics teaching developed at Arizona State University. This approach focuses less on teaching students specific physics concepts and shifts the focus to the determination of physical and mathematical models that explain specific phenomena. This approach helps students develop skills in scientific discourse, but it does not allow students exposure to engineering applications for their knowledge. My plan seeks to include the opportunity for my physics students to develop their physics knowledge in a modeling context while using that knowledge in engineering contexts.

Also, I will begin teaching a full year of Calculus starting in September 2010. I have never taught Calculus before, but my goal is to integrate the Physics and Calculus courses on a level that allows a comprehensive experience for students in each class, or for students in both classes. I am looking to create a capstone experience that can run parallel to the Physics capstone experience, and one that more closely mimics the capstone experience that would be completed in mathematics (analysis of data, creation of mathematical models, etc. as a way to understand physical systems).

CONTEXT

1. CURRENT STATUS OF ENGINEERING EDUCATION AT NCCES. In our school, our ninth grade students complete the full Engineering the Future curriculum in preparation for the Science, Technology and Engineering MCAS. Other engineering projects and applications are scattered throughout our middle school courses, and are relatively thin in our upper-level theoretical courses. We do not have computer labs with dedicated drafting software or tools.

2. GRADUATION REQUIREMENTS. We currently require three years of mathematics and three years of science in order to graduate. STEM education is viewed as very valuable in our school.

CLASSES TAUGHT

- PHYSICS. I teach a single period (full-year) of Physics that is based on a Modeling Physics approach similar to the Modeling Instruction approach developed at Arizona State University. This approach emphasizes the development of models in

order to understand physical phenomena. Our course begins with quantum theory about the behavior of light in order to help students learn how scientists use data to develop models for the way that the world behaves. From there, we move on to studying motion by developing mathematical models of motion data. This approach also helps students learn how scientists refine the models they make based on new observations and theoretical considerations. From this initial understanding, students develop statistical models from numerical data in order to understand physical systems.

- CALCULUS. For the first time, I will teach a full-year course in single-variable calculus. This course will cover both differential and integral calculus.

- NINTH GRADE INTEGRATED PHYSICAL SCIENCE. I will also teach two sections of a course called Integrated Physical Science, which is taught to all of our ninth graders. This course guides students through each project in the Engineering the Future curriculum, and fits very closely with our school as an Essential School.

ACTION PLANS

1. DEVELOP AND IMPLEMENT A MINI DESIGN CAPSTONE FOR PHYSICS TO COMPLETE AT THE END OF SEMESTER ONE. I plan to close the first semester of Physics with a unit on Forces (where I also teach momentum, impulse-momentum theorem, friction, and other related topics). In order to introduce Newton's Laws of Motion, forces, and momentum in a meaningful way, I will ask students to complete a design capstone focused around investigating and implementing improvements to a basic Mousetrap Car using their knowledge of forces and energy. I will complete this work with Josh Miranda from Revere High School and Mike Graeber from Hopkinton High School.

2. DEVELOP AND IMPLEMENT A FULL CAPSTONE EXPERIENCE FOR PHYSICS TO COMPLETE AT THE END OF SEMESTER TWO. My plan for the second semester of Physics is to cover topics in modern physics, such as energy (in mechanical and electrical contexts), electromagnetic theory, nuclear physics, relativity, and other topics depending on time. I would like to concurrently run a full-semester capstone that uses this knowledge to inform engineering design work. The outline for this capstone experience is attached; I will work with Josh Miranda to complete this outline.

3. DEVELOP AND IMPLEMENT A MATH-BASED CAPSTONE EXPERIENCE IN CALCULUS THAT MATCHES THE WORK OF THE PHYSICS STUDENTS IN THEIR CAPSTONE. After teaching Calculus in the 2010-2011 school year, I would like to develop a capstone that asks students to investigate the statistical and mathematical connections in the capstone work of the Physics students. This is work

that will come after I have taught Calculus for a year, and after the Physics students have completed the capstone experience I have developed for them.

TIMELINE

- Complete the development of the Mini-Capstone on the Mousetrap Car by September 2010, and implement this project in January 2011. Document completion of the experience and report to the CAPSULE group by February 2011.
- Complete the development of the Capstone in Physics by January 2011, and implement this project in February 2011. Document completion of the experience and report to the CAPSULE group by July 2011.
- Complete the development of the Capstone in Calculus by September 2011.

ATTACHED DOCUMENTATION

The following attached documentation goes with this implementation plan:

- The outline for the final Physics Final Capstone;
- The outline for the Physics Mini Capstone Experience based on the Mousetrap Car.