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Physics 690

An Examination of the Modeling Curriculum for Teaching Physics and How it can be used in New York State Based on the New York State Physics Core Curriculum

ABSTRACT

The following is an analysis of the ASU-Hestens Modeling Curriculum. This analysis was done in order to map the second semester of the Modeling Curriculum to the New York State Regents standards found in the Core Curriculum. The second semester of the Modeling Curriculum contains electricity and magnetism as well as the particle and wave theory of light. At the conclusion of the analysis some suggestions are made as to use the Modeling Curriculum to meet the New York State Standards as well as to fill the seemingly un-represented curricula issues.

INTRODUCTION

In New York State, the physics curriculum is set by the New York State Core Curriculum (NYSCC), which includes the New York State Standards (NYSS). The purpose of the NYSCC, is to guide a teacher through the NYSS, in order to fully prepared their students to pass the New York State Regents examination.[1] However in recent years the level of the Physics Regents has increased in areas such as the conceptual understanding of physics phenomena as well as the reading level of the exam.[2] With the increased level of difficulty on the New York State Regents Exam in Physics, an alterative method in teaching may be utilized to help students attain a level of not only passing (65%), but a level of excellence (85%) on the examination as well as a higher level of understanding on the material being presented. One curriculum to address this is the Modeling Curricula for teaching high school physics, which was designed for the purpose of raising students conceptual understanding of physics.[3]

MODELING METHOD TO TEACHING PHYSICS

According to Malcolm Wells and David Hestenes educational research, the modeling method stems from student centered learning, which is essential in order for meaningful learning to take place. The modeling method incorporates a student centered instructional design promoting an integrated understanding of physical phenomena.[3]

The modeling method and instructional goals and objectives are as follows:

(Wells, 1995)

- To engage students in understanding the physical world by constructing and using scientific models to describe, to explain, to predict and to control physical phenomena.
- To provide students with basic conceptual tools for modeling physical objects and processes, especially mathematical, graphical, and diagrammatic representations.
- To familiarize students with a small set of basic models as the content core of physics.
- To develop insight into the structure of scientific knowledge by examining how models fit into theories
- To show how scientific knowledge is validated by engaging students in evaluating scientific models through comparison with empirical data.
- To develop skills in all aspects of modeling as the procedural core of scientific knowledge.

REASONS FOR MODELING

Before physics instruction, students hold beliefs about physics concepts in most respects. Such beliefs are a major determinate of student performance in introductory physics. "Traditional (lecture-demonstration) physics instruction induces only a small change in beliefs. This result is largely independent of the instructor's knowledge, experience and teaching style."[3] The New York State Regents Examination has increased in difficulty, particularly in conceptual understanding.[2] Research shows that a when comparing scores from the Force Concept Inventory, which is an instrument that tests conceptual understanding of physics, traditional methods of teaching showed an average gain of 22 %.[4] "Students learn most effectively when they have a central role in the discovery process."[1] In contrast to traditional instruction, using non-traditional, research based methods such as the modeling method for teaching physics, showed an average gain of 52 %.[3] It is through the non-traditional research based physics teaching such as the modeling method that maximizes student understanding and such large gains of conceptual knowledge.

New York State Core Curriculum

The Physical Setting/Physics Core Curriculum has been written to assist teachers as they prepare curriculum and instruction for the physics content and process skills of the New York State Learning Standards for Mathematics, Science and Technology. The key ideas are broad and general statements of what the students need to know. "The core curriculum guide is not a syllabus. It addresses the content and process skills as applied to the rigor and relevancy to be assessed by the in the Physics Regents Examination."[1] The NYSCC for physics includes standards 1, 2, 6 and 7 which incorporate a student centered, problem solving approach to physics. These standards include but are not limited to:

- Standard 1 Mathematics and scientific inquiry:

  Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to propose questions, seek answers, and develop solutions.

- Standard 2 Information systems:

Students will access, generate, process, and transfer information, using appropriate technologies.

- Standard 6 Interconnectedness: Common Themes:

  Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

- Standard 7 Interdisciplinary Problem Solving:

  Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

In addition to this standard 4 is explicitly designed for the physical science setting. The key ideas in standard 4, was to design a standard that outlines:[1]

1. Energy exists in many forms, and when these forms change, energy is conserved.
2. Explain variations in wavelength and frequency in terms of the source of the vibrations that produce them.
3. Energy and matter interact through forces that result in changes in motion.
4. Compare energy relationships with an atom's nucleus to those outside the nucleus.

In addition to the skills outlined by the NYSS, the NYSCC includes a prerequisite for admission to the Physics Regents Examination; students must have successfully completed a minimum of 1200 minutes of hands on laboratory experience with satisfactory documentation on file.

ANALYSIS

My analysis of the Modeling Curriculum was for what the curriculum calls the second semester that includes electricity and magnetism, as well as the particle and wave theory of light. This analysis includes mapping out the second semester of a physics class as it would be taught according to the New York State Core Curriculum, and comparing how the Modeling Curricula covers the same material. The Core Curriculum that was analyzed for this comparison were the Science, Mathematics, and Technology standards as well as standard 4 which is also known as Regents Physics.[1] We are concerned about those standards in the NYSCC that are not addressed at a minimum of three times throughout the semester and a minimum of four times for those standard 4 topics associated directly with Regents Physics. The second semester of the modeling curriculum contains six units. Each unit was analyzed and broken down into tables 1-6 distributing individual units in the modeling curriculum, and how that unit is applicable to the NYSS. Each unit of the modeling curriculum is further broken down into individual activities. A complete break down of how each activity is applied to the NYSS as each activity appears in the modeling curriculum, is shown in the corresponding tables 1a-6a, and they are sorted in the order of the standards. In addition, tables 1b-6b show each activity and the standards that apply to each in order of modeling activities. Table 7 is a complete tally of all six units, showing exactly how many times each standard is utilized or not utilized over the entire semester. Table 8 is an explicit tally of those NYSS that I believe are not adequately addressed by the standard Modeling Curricula.

FINDINGS AND DISCUSSION:

This is an examination of electricity and magnetism as well as the particle and wave model of light only. The seeming "missing sections" addressing NYSS relevant to the mechanics standards are addressed in an accompanying paper analyzing the modeling method for teaching mechanics.[5]

The Modeling Curricula is distributed in a format unique from other curricula and textbooks. The Modeling Curricula is distributed in a paper format and an electronic format that is purposely distributed as a text file. The reasoning for this is that unlike textbooks, Modeling Curricula activities may be modified or edited by teachers to address their teaching styles as they feel necessary. Modifications may also be made that could alter the present activities to incorporate more or all of the NYSS. For example, in addition to the Modeling Curricula a teacher can branch out for additional recourses for teaching electricity and magnetism. Such resources include the Castle curricula. The Castle curricula can be used to make possible additions and modifications in order to meet the NYSS[6, 7] In discussion with Chris Filkins, a teacher at Fredonia High School who teaches Regents Physics with the Modeling Curricula, he finds that much of the electricity and magnetism is not only supplemented by the Castle material but the two are complementary to each other .[6]

The largest area of un-represented material in the Modeling Curricula as compared to the NYSS are those atomic and modern physics concepts such as those of Standard 4, Key Idea 5.3 "Compare energy relationships within an atom's nucleus to those outside the nucleus." There are no applicable parts of the Modeling Curriculum that cover this type of material. To teach this section of the NYSS, outside materials can be obtained through programs such as the Contemporary Physics Education Project (CPEP).[8] CPEP offers many hands on activities and labs that students can do in order to obtain optimal understanding.

Although modeling imports many activities which may be used as lab activities, a possible concern in teaching from the modeling curriculum is that documentation of the 1200 minutes of laboratory activities may be lacking. In order to teach the modeling curriculum effectively a strategy known as white boarding may be used. A white board is a 32" x 24" piece of white tile board. Groups of 2-4 students are given whiteboards and dry erase markers and asked to answer conceptual problems in approximately 20 minutes. In order to document this time affectively, digital photographs may be appropriate while students are collaborating on the whiteboard work. Whiteboards are collected and coarsely group graded, related problems are given on exams and homework. Whiteboard problems are typically modified from curricular materials.[9] At the conclusion of the white boarding activity, a variation of the following can be done in order to fully utilize the potential of the activities.[10]

- Student discourse is anchored in the collaborative construction of solutions to abstract problems on their whiteboards rather than focused on real apparatus.
- No round-robin group presentation is made at the end, though groups may be called upon during an instructor-led debriefing.
- White boards may also be created in explaining classroom demonstrations for elaborate systems in order to explain physical phenomena. Formal lab write-ups can be produced along with the aid of photographs for documentation of laboratory time.

Attached tables (Microsoft excel sheets)

Chart 1, Tables 1-6 (ModelingE&Mchart1July04)

Table 1a (ModelingE&Mtable1aJuly04)

Table 1b (ModelingE&Mtable1bJuly04)

Table 2a (ModelingE&Mtable2aJuly04)

Table 2b (ModelingE&Mtable2bJuly04)

Table 3a (ModelingE&Mtable3aJuly04)

Table 3b (ModelingE&Mtable3bJuly04)

Table 4a (ModelingE&Mtable4aJuly04)

Table 4b (ModelingE&Mtable4bJuly04)

Table 5a (ModelingE&Mtable5aJuly04)

Table 5b (ModelingE&Mtable5bJuly04)

Table 6a (ModelingE&Mtable6aJuly04)

Table 6b (ModelingE&Mtable6bJuly04)

Table 7 (ModelingE&Mtable7July04)

Table 8 (ModelingE&Mtable8July04)

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