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Science House Physics Curriculum

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Abstract

If one believes learning is difficult, they should try designing a curriculum. Curriculum designers must create an interactive environment and syllabus for students to be part of, while at the same time address all the local, state and federal learning requirements, design a curriculum to stay within a school budget and have it tailored to multiple learning styles. To create such a curriculum is difficult; now compile the same curriculum to span instruction of students from elementary school through high school. Physics curriculum over this span must cover eight primary topics: scientific inquiry, linear motion, two-dimensional motion, forces and Newton's Laws of Motion, impulse and momentum, energy, wave motion and wave nature of light, and finally static electricity and circuits (The Science House [TSH], 2006).

Science House Physics Curriculum

Introduction

The North Carolina State University *Physics Curriculum Resource Guide* (TSH, 2006) lays out a curriculum in direct correlation to the standard course of study outlined by the Public Schools of North Carolina (Public Schools of North Carolina, 2004) for Kindergarten to twelfth grade. This curriculum was selected for analysis and review due to its extensive topic coverage area within Physics and hands-on applications, for its use at multiple grade levels and its alignment with state requirements. Educated Physics instructors, students eager to learn, and parents and administrators willing to support the Physics programs and students are all that is needed to create an extensive, effective learning environment. The Science House (TSH, 2006b) who has sponsored this curriculum also assists in providing professional development training and education to the instructors utilizing their curriculum, sponsored science conferences for their students, and provides additional online activities, curricula and materials for students and instructors.

Curriculum Review

The curriculum provided by Science House covers eight primary goal areas within the Physics curriculum: (a) scientific inquiry, (b) linear motion, (c) two-dimensional motion, (d) forces and Newton's Laws of Motion, (e) impulse and momentum, (f) energy, (g) wave motion and wave nature of light, and finally (h) static electricity and circuits (TSH, 2006). Within each of these goal areas specific objectives are also outlined. Each of these objectives is directly correlated, or a direct duplication, of the state of North Carolina Standard Course of Study for Physics competency goals in science (Public Schools of North Carolina, 2004).

Scientific Inquiry

Goal one states "the learner will develop abilities necessary to do and understand scientific inquiry" (TSH, 2006c). Five ordered objectives are defined within this goal, covering the identification of questions to be answered by the scientific process, the construction and execution of scientific exploration, logical revision of the scientific process, identification and use of safety procedures throughout the analysis process, and the analysis of investigation reports (TSH, 2006c). Lesson plans and activities provided to the students range from bridge building projects for fifth to twelfth grade students with an aim to build the lightest scale bridge which is capable of holding the most weight, or the White Box Activity (TSH, 2006d) for middle school and high school students, where students must figure out what his contained within a sealed box purely by scientific inquiry.

Linear Motion

Goal two states "the learner will build an understanding of linear motion" (TSH, 2006e) and then goes on to list the four objectives in order to obtain this goal: (a) "analyze velocity as a rate of change of position: average and instantaneous velocity," (b) "compare and contrast as scalar and vector quantities: speed & velocity and distance & displacement," (c) "analyze acceleration as rate of change in velocity," (d) "using graphical and mathematical tools, design and conduct investigations of linear motion and the relationships among: position, average velocity, instantaneous velocity, acceleration and time" (TSH, 2006e). Lessons and activities to address the understanding of linear motion range from junior and senior high school students *Velocity and Racecars* lab in which they utilize real-time motion detectors and graphing software to analyze a racecars movements (TSH, 2006f), to a freshman and sophomores ability to simply identify points of acceleration, constant speed and no motion on a series of charts.

Two-Dimensional Motion

Goal three states “the learner will build an understanding of two-dimensional motion including circular motion” (TSH, 2006g). This goal contains six supporting objectives covering projectile and two-dimensional motion analysis, circular and centripetal force analysis and its relation to mass, radius and velocity (TSH, 2006g). Lesson activities range from projectile observations of angle and arc distance by third to fifth grade students (Ingram, n.d.), middle school students measuring muzzle velocities and projectile angles to predict distance (Cunningham, n.d.), to high school students learning the use of STELLA to model projectile motion and the x- and y-displacement of objects fired at different angles (Ragan, n.d.).

Forces and Newton’s Laws of Motion

Goal four states “the learner will develop an understanding of forces and Newton’s Laws of Motion” (TSH, 2006h). Seven objectives uphold this goal: (a) “determine that an object will continue in its state of motion unless acted upon by a net outside force,” (b) “assess, measure and calculate the conditions required to maintain a body in a state of static equilibrium,” (c) “assess, measure, and calculate the relationship among the force acting on a body, the mass of the body, and the nature of the acceleration produced,” (d) “analyze and mathematically describe forces as interactions between bodies,” (e) “assess the independence of the vector components of forces,” (f) “investigate, measure, and analyze the nature and magnitude of frictional forces,” and finally (g) “assess and calculate the nature and magnitude of gravitational forces” regarding universal gravitation (TSH, 2006h). Force and motion activities provide a wide range of activities, third to sixth grade students can learn the difference in inertias with a couple of carts (Walker, n.d.), while high school students can calculate the mass of the Earth through universal gravitation (Harpell, n.d.).

Impulse and Momentum

Goal five states “the learner will build an understanding of impulse and momentum” (TSH, 2006i). Following this are five objectives including assessing “the vector nature of momentum and its relation to the mass and velocity of an object,” analysis of impulse, momentum and the changes in momentum, one-dimensional conservation of momentum, and finally real-life momentum and impulse applications. To understand impulse and momentum, middle school students can discover impulse via Bungee Barbie labs (TSH, 2006j), while high school students can identify elastic and inelastic collisions via the collision of various balls (Rich, n.d.).

Energy

Goal six states “the learner will develop an understanding of energy as the ability to cause change” (TSH, 2006k). This understanding is supported with four major objectives including the understanding the transfer of energy, conservation of energy, and work, energy and power interactions. High school students can rig pulley systems to help identify work (Economou, n.d.), or understand friction and energy loss via spring driven carts and the kinetic and potential energy transfers (Szeszol, n.d.).

Wave Motion and Wave Nature of Light

Goal seven states “the learner will develop an understanding of wave motion and the wave nature of sound and light” (TSH, 2006l). Seven additional objectives support this goal including an investigation into wavelength, frequency, period and amplitude, identifying waves in different mediums, identify and define reflections and wave refractions, superpositioning, and wavelength and frequency of sounds (TSH, 2006l). To assist in the understanding of waves, high school students can study the waves produced by guitars (Kulak, n.d.) to understand the string length and vibrations, wave patterns and characteristics, or an analysis of "images formed by plane, cylindrical and spherical mirrors" to discover wave nature in different mediums (Szeszol, n.d.2).

Static Electricity and Circuits

Finally, goal eight states "the learner will build an understanding of static electricity and direct current electrical circuits" (TSH, 2006m). Analyzing electrical charges, current, resistance, potential differences, comparing and contrasting parallel and series circuits, and finally understanding power within a circuit are the primary objectives associated with this goal. Lightning patterns can be analyzed by student grade six to twelve in order to assist in the understanding of electricity (Scurletis & Anderson, 2002), while ninth to twelfth grade student can actually create their own circuit backpack alarm (Torpie, n.d.).

All Physics labs should have access to a multitude of supplies, like motion detectors, computers and software for real-time collection, carts and weights, balls, projectiles, strings, waterguns and tape measures, springs and stopwatches, thermometers, beakers, blocks and balances, wave mediums, circuit boards, resistors, capacitors and power sources.

Curriculum Evaluation Model

"While the objectives-based approach is not the only approach for evaluating programs, it is appropriate for projects that use specific objectives to direct program activities" (Ricker, Brown, Leeds, Leeds, Bonar Bouton & Vogstadt, 1998). Ralph Tyler's objective-based evaluation method is one of the most direct and encompassing evaluation methods which ties direction into the curriculum and structure of the Science House's curriculum. Tyler believed that goals must first be defined and then objectives classified (Lewis, 2003). Since the Science House made a considerable point of aligning their curriculum with the state of North Carolina's standards they directly come from the state standard requirement goals, and objectives to obtain said goals. Subsequently, curriculum should define situations, lessons or activities which support the achievement of the specifically defined objectives. This is exactly what the Science House does by providing a variety of lesson plans, web sites and additional resources to assist in the construction and execution of these lessons (Lewis, 2003).

Assessment Tools

Content can stray from its ideal standards in two primary ways: “content in the standards may not be assessed, and content assessed may not be in the standards” (Porter, 2004, p. 9). When President Bush passed the No Child Left Behind Act of 2001 (U.S. Department of Education, 2007) the federal government mandated “that each state align assessments to content standards. If the content assessed is exactly the same as the content represented in the standards, alignment is perfect” (Porter, 2004, p. 9), this is generally a very tedious and time consuming process. However, the American Association for the Advancement of Science, with assistance from the National Science Foundation, is constructing a new math and science standards and content assessment tool entitled Project 2061 (2007). Project 2061, will assist in defining goals alignments with standards, objectives alignment with goals, and content alignment with objectives. Eventually, Project 2061 will be able to define test, lesson and activities alignment with course content and state and federal standards. In the meantime, however additional formative and summative evaluation steps need to take place. Formative evaluations like “…interim assessments or quizzes…can serve to elicit students’ thinking, feedback can be used to encourage student to confront their misconceptions, and the process itself can be instrumental in helping students move to higher levels of understanding (Gitomer & Duschl, 1995)” (Herman, Osmundson, Ayala, Schneider, & Timms, 2006, p. 2). Finally comes the summative evaluation in which the outcome and impact of the curriculum shall be defined, including a cost benefit analysis. Although budget is not addressed within the Science House curriculum at all, it is beneficial to address and can have great impact on whether a curriculum is implemented or not.

Conclusion

Curriculum comes in many forms, spans multiple grade levels and has a multitude of local, state and federal requirements associated with it. Within a single subject area, like Physics, there can be one, ten, or even a hundred topics which must be addressed by instructors and students must learn. The Science House provides a comprehensive physics curriculum for students, elementary through high school. The curriculum is perfectly aligned with the state standards and provides a significant number of lesson plans, activities, applets, and other resources for instructors to use within their learning environment. In addition the Science house provides professional development training directly to instructors who utilize their curriculum, and support a variety of other events and informational tools for both students and instructors.

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Appendix A

The Science House curriculum can be found at http://www.science-house.org/learn/Physics/