North Carolina Department of Public Instruction

Technology Education Computational Science Proposal

Narrative and Proposal Overview

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Technology Education Computational Science Proposal

Scope and Sequence

Background

The Department of Public Instruction Program Area of Technology Education proposes the following seven courses to be offered over a period of six years as part of the Computational Science high school program:

- Scientific Visualization - Biology
- Scientific Visualization–Physical Sciences
- Scientific Visualization–Environmental Sciences
- Scientific Visualization–Social Sciences
- Virtual & Physical Modeling–Algebra 1
- Virtual & Physical Modeling–Geometry
- Virtual & Physical Modeling–Algebra 2

These courses, also called companion courses, will be paired with the courses named in each title, respectively. This proposed program integrates three curricula: science, technology and math. Engineering concepts and principles will be drawn from each of these areas. The courses from each of these areas will vary according to local needs, students served, and desired outcomes. Student participants will form a cohort grouping, being enrolled in one pair of companion courses during the same time period. For example, a student would be enrolled in Biology and Scientific Visualization—Biology during the same semester.

The following table details the proposed models:

Table 1: Proposed STEM Models

Science Models	**Technology**
Biology	Scientific Visualization–Biology
Physical Science	Scientific Visualization–Physical Science
Earth & Environmental Science	Scientific Visualization–Earth & Environmental Science
Social Science	Scientific Visualization–Social Science
Mathematics Model	**Technology**
Algebra I	Virtual & Physical Modeling–Algebra I
Algebra II	Virtual & Physical Modeling–Algebra II
Geometry	Virtual & Physical Modeling–Geometry

Purpose

The project has several purposes:

- Develop improved instructional processes
- Increase student learning outcomes in math, science, and technology
- Increase student retention–decrease student dropout rate
- Increase enrollment and completion of post-secondary education with emphasis placed on community college articulation
- Increase student interest in math, science, technology and engineering
- Test the following assumptions

Assumptions

The project will assess the following assumptions:

- An integrated curriculum is more interesting to students
- Academic concepts and principles applied to practical subjects become more meaningful to students and result in greater appreciation of the academic and technical areas being studied
- The weaving and repetition of the same core concepts and principles in several different courses will lead to increased student academic performance
- The inclusion of academic concepts and principles in CTE courses will permit more complex technical concepts and principles to be addressed
- An integrated approach to instruction will result in higher student retention
- STEM programs and academies will increase student enrollment and success in post-secondary institutions

Narrative and Proposal Overview

The President's Information Technology Advisory Committee[1] writes: "Computational Science—the use of advanced computing capabilities to understand and solve complex problems—has become critical to scientific leadership, economic competitiveness, and national security. The PITAC believes that computational science is one of the most important technical fields of the 21st century because it is essential to advances throughout society" (p. iii). The report continues: "Global competitors are increasingly testing U.S. preeminence in advanced R&D and in science and engineering-based industries" (p. 7). Further, the PITAC states: "We are now at a pivotal point, with generation-long consequences for scientific leadership and economic competitiveness if we fail to act with vision and commitment" (p.18).

The Technology Education leadership is proposing to expand our current program by adding two science-focused and three mathematical-focused companion courses. Beyond the

[1] *Computational Science: Ensuring America's Competitiveness 2005*. President's Information Technology Advisory Committee. Arlington, VA

argument offered by the PITAC, there are two others directly related to CTE's mission. The first argument is predicated on the new Perkins Act, and the second, on pedagogical theory.

First, the new Perkins legislation requires CTE to take greater responsibility in helping students understand and apply academic concepts. The Computational Science Program clearly does this well and perhaps better than any other CTE program. Second, the pedagogical assumption is that STEM strategies make sense and work. For the purpose of this proposal, a STEM project is defined as the integration of three curricula: science, technology and math. STEM is essentially an integration strategy. There is ample research evidence that curriculum integration works.

A strategy of pairing two courses together as companion courses, rather than trying to link three courses, makes for a more focused approach as well as an easier approach to implement, and ultimately, more effective. Designing companion SciVis courses for a particular science such as biology makes it easier to stay focused on the specific "essential science ideas." Further, companion courses enable administrators to sequence the course to reflect the sequencing used in the state's science program.

This same pedagogical argument is also our rationale for the proposal of the Mathematical Modeling and Analysis sequence. However, there is a difference between the science and mathematics computational sequences, in that the mathematics courses will incorporate much more physical modeling than the science sequence, which relies primarily on virtual modeling.

While STEM strategies serve both gifted and at-risk students well, the Computational Science Program would permit academically struggling students to apply simple and complex modeling tools to better understand science, technology, engineering, and mathematics concepts and principles. The strategies incorporated in this program will make it possible for many students who would otherwise flounder in traditional settings, to reach a high degree of technical and academic attainment.

Anecdotal evidence at Page High School in Greensboro, NC is very promising that companion courses improve academic outcomes.

Research

A Harvard research study (Rumberger, 2001) on the causes of dropouts reports the following: "Recent concern for dropouts is also fueled by a number of economic, demographic, and educational trends that could exacerbate this problem in the future. One trend is economic: as the United States economy moves toward a higher-skilled labor force, high school dropouts will have an even harder time surviving economically (Murnane & Levy, 1996). A second trend is demographic: the number of students who are generally at greater risk of school failure—students from poor and low-income households, racial, ethnic, and linguistic minorities—are increasing in the nation's schools (Levin, 1986; Natriello et al., 1990). The third trend is the growing push for accountability in the nation's public schools that has produced policies to end social promotion and to institute high school exit exams, both of which could increase the number of students who fail to complete high school (Heubert & Hauser, 1999)."[2]

[2]Rumberger, Russell W. (2001). Why Students Drop out and What Can Be Done. Paper prepared for the Conference, Dropouts in America: How Severe is the Problem. Harvard University. http://www.civilrightsproject.harvard.edu/research/dropouts/rumberger.pdf

Studies continue to show that students in the United States lag behind other industrialized nations in science and mathematics achievement. Results from the Trends in International Mathematics and Science Study (TIMSS, formerly known as the Third International Mathematics and Science Study) showed that out of 45 countries, U.S. students placed 15th in mathematics and ninth in science. [3]

Traditional classroom approaches that worked a century ago seem to have lost their relevance, whereas science, technology education, engineering, and mathematics (STEM) curricular approaches pioneered in North Carolina are showing promise, both in engaging students' interest and in improved academic achievement in courses of science, technology education, and mathematics. Since student engagement has been shown as a key ingredient for keeping students enrolled (Rumberger, 2001), along with improved academic achievement (Ekstrom et al., 1986; Goldschmidt & Wang, 1999; Rumberger, 1995; Rumberger & Larson, 1998; Swanson & Schneider, 1999; Wehlage & Rutter, 1986, Rumberger, 2001), this research team suggests that the use of STEM integrated curricula in teaching science, technology, and mathematics courses combined with training teachers in the latest intervention methods would be an effective intervention for reducing the high school dropout rate.

The attrition rate among students between the ninth and twelfth grades accelerates at an alarming rate: "some 45,000 students drop out over the course of four years.[4]" Of the 60% who do graduate, about two-thirds immediately enter college, but only two-thirds of those are still enrolled in their second year, and less than half graduate with an associate's degree within three years or a bachelor's degree within six years (r3, 2005).

For every 100 ninth grade students in North Carolina:

- 60 graduate four years later
- 41 enter college
- 29 are still enrolled in their second year
- 19 graduate with associate/bachelor degree within six years. (National Center for Public Policy and Higher Education, 2004)

Almost as disturbing as the dropout rate is the fact that students are graduating either totally unprepared or ill prepared for college or work:

- 60% of employers rate students' basic skills as "fair" or "poor"
- 36% of students graduate from high school unqualified or marginally qualified to go to college
- 53% of students took at least one remedial course during their college careers
- Only 58% of UNC System students complete a bachelor's degree within six years of their freshman year.

[3] Trends in International Mathematics and Science Study. TIMSS 2003 Results. http://nces.ed.gov/timss/Results03.asp

[4] r3--Rigor, Relevance, and Relationships: A Vision for High Schools in North Carolina that Succeed for all Students. North Carolina Action Plan for High School Innovation. 2005. An initiative of the North Carolina Education Cabinet and the Public School Forum of NC with the support of the Bill and Melinda Gates Foundation. www.newschoolsproject.org

- Remedial training in reading, writing and mathematics to a single state's employers costs an estimated $40 million a year.[5]

In North Carolina —as in many other states— the student dropout rate has become a major concern. Costs to society are seen in other ways:

- A high school dropout in 2000 had less than a 50 percent chance of getting a job. That figure drops to 25 percent for African-American students.
- The dropout's job will earn less than half of what the same job earned 20 years ago.
- Wages are increasing only for those with at least a college education.
- Lack of education is increasingly correlated with incarceration and dependence on welfare (School Redesign Network, 2002).

For the companion courses with which the academic courses are being paired, the companion course curriculum will draw on technology education teachers' expertise in developing physical and virtual modeling activities. Wonacott (2001) asserts that Career and Technical Education (CTE) can present considerable benefits for at-risk students. Brown (2003) indicates through a synthesis of research that at-risk students, disadvantaged students, and students with disabilities experience a heightened degree of employment success, knowledge retention, and academic success when enrolled in technology education, technical preparation, school-to-career, and other CTE programs. A research study by Colley and Jamison (1998) indicates that students at-risk or with disabilities in secondary CTE programs were less likely to drop out of school than students at risk or with disabilities not enrolled in CTE. The study also suggested that at-risk students and students with disabilities enrolled in secondary CTE programs are more likely to be employed, to have paid competitive jobs, and to work full time after high school than at-risk students and students with disabilities not enrolled in CTE.

The Importance of STEM Content Integration

Hevesi (1999) reports a research study conducted by the Comptrollers Office in the city of New York that identified three major skill and knowledge indicators of workforce success after high school: (1) mathematics competency, (2) science competency, and (3) technological competency. The research indicated that students are poorly academically prepared in mathematics and science in early grades, hampering knowledge growth in advanced mathematics and science courses in later educational endeavors. The research also indicated a teacher training shortage in mathematics and science disciplines. An evaluation of the findings from the study led to a researcher recommendation of integrated content across science, technology, and mathematics (STEM) with a supportive teacher professional development structure.

Strategic Rationale: Unique Features of this Proposal

There are several reasons why this project should be implemented. The first two are its timeliness and its imperative need. At no time in recent history has there been more concern voiced (by policy leaders, practitioners and citizens) for acting on the problems that call for high school reform. Secondly, this project offers a systemic solution to achieving its goals. By developing curricula offered as companion courses to academic courses taught in every high school in North Carolina, schools will not be required to implement major changes in course

[5] Ibid.

offerings. However, adopting this project's strategies will entail a major change in the way science, technology (applied engineering), and mathematics education programs are offered. Finally, the project addresses the spirit and intent of the national No Child Left Behind legislation—serving all children well by providing them with an education that enables them to become responsible, contributing and participating citizens.

Using a research-proven development model (Tech-know, VisTE), curriculum-writing teams consisting of STEM content experts representing science and mathematics education teachers, in each content area, will use North Carolina's EOC database to identify the subset of competencies to serve as the focal content pieces for the curriculum, respectively. The subsets of competencies are identified as the areas in which students in the state of North Carolina exhibit the greatest deficit. While the project team will be using the Tech-know and VisTE curriculum development model, it should be noted that the curricula to be developed will be completely different from that developed in these projects. The difference is in the content: whereas TechKnow and VisTE developed STEM curriculum matched to STL standards, this project team proposes the development of technology education companion courses to be paired with high school science and mathematics education courses. This focus is significant in light of student scores on standardized mathematics and science tests. Those scores reflect the difficulty that many students are having in grasping concepts in both areas.

Companion Course Curriculum

The integrated STEM curricula designed and implemented by the STEM team will focus on the most important, enduring, and fundamental concepts found within the prospective science, technology, and mathematics education courses to be taught. The curriculum writing team and project teachers will develop instructional materials such as lesson plans, activities, and formative and summative assessment instruments.

These materials will be challenging, interesting, and will reflect real world applications. Activities will be designed to demand the integration and application of academic concepts in the development of technology projects. Students will be expected to be self-directed as well as to participate as members of teams to solve problems.

Technology education companion course curricula will be developed for Biology I, Physical Science, Environmental Sciences, Social Sciences, Algebra I, Geometry, and Algebra 2 entitled "Scientific Visualization–Biology I;" "Scientific Visualization–Physical Science," "Scientific Visualization–Environmental Sciences," "Scientific Visualization–Social Sciences," "Virtual and Physical Modeling–Algebra I"; "Virtual and Physical Modeling–Geometry"; and "Virtual and Physical Modeling–Algebra II." These seven companion courses will introduce students to practical applications of mathematical and scientific content by addressing a subset of competencies in the existing core academic courses selected. Students will experience course material through virtual and physical modeling activities that require the application of specific academic competencies. Virtual modeling, for the purposes of this project, consists of the creation of data or concept driven graphical representations of mathematical and scientific content. Physical modeling, for the purposes of this project, is the construction of scaled devices that are data or concept driven representations of mathematical and scientific content. Theses companion courses heavily rely on student engagement through the hands-on nature and practical (real-world) applications of the content. The core academic-based content is communicated through Career and Technical Education constructivist methods and applications, both of which have proven track records with at-risk students; that is, with such methods, students have previously experienced great successes (Brown [2003]). Seven teams—a Scientific Visualization–Biology I curriculum team, a Scientific Visualization–Physical Science curriculum team, a Scientific Visualization–Environmental Sciences curriculum team, a Scientific Visualization–Social Sciences curriculum team, a Virtual and Physical Modeling –Algebra I curriculum team, a Virtual and Physical Modeling–Geometry curriculum team, and a Virtual and Physical Modeling–Algebra II curriculum

team—will each develop course blueprints and curriculum guides including content organizers, instructional activities, and activity assessments for all competencies and objectives identified. Each blueprint will include units of instruction, competencies in each unit, and the specific objectives for each competency. Further, the blueprint will illustrate the relative weight of the units, competencies, and objectives within the course. Each competency and objective will reflect the intended level of learning through two dimensions based on Lorin Anderson's Revised Bloom's Taxonomy (RBT): 1) The Knowledge Dimension and 2) the Cognitive Process Dimension. Each curriculum team will develop content organizers and instructional activities by "unpacking content" (that is, by breaking down and identifying the most important concepts in a way most easily understandable to students).

Perkins Act of 2006

The Scientific Visualization sequence strongly reflects the Perkins IV legislation. Section 113 contains core indicators reflecting student attainment of challenging academic content standards and student academic achievement standards and high student graduation rates (p. 76-77). Section 118 speaks to the expectation of coursework that leads to high skill, high wage, or high demand occupations (p. 79-80). Section 121 expects to see CTE programs that "include coherent and rigorous content aligned with challenging academic standards and relevant career and technical content in a coordinated-non-duplicative progression of courses…. To adequately prepare students to succeed in postsecondary education." Local plans are expected to "promote continuous improvement in academic achievement; promote continuous improvement of technical skill attainment; and identify and address current or emerging occupational opportunities; (show) how programs at the secondary level will prepare career and technical education students, including special populations, to graduate from secondary school with a diploma, …"

RBT

These courses will be developed using the RBT. Each competency and objective of these courses will reflect the intended level of learning through two dimensions based on Lorin Anderson's Revised Bloom's Taxonomy (RBT): 1) The Knowledge Dimension and 2) the Cognitive Process Dimension.

The American Diploma Project and 21st Century Skills

This sequence is especially designed to help struggling students who have had difficulty with science, complex technical, engineering, and mathematics concepts. The sequence reflects the rigor, relevance, and relationship called for through the American Diploma Project and 21st Century Skills.

New CTE Standard Course of Study

These courses will meet all the standards of the new CTE Standard Course of Study.

Appendix A

Site Requirements

- Administration and Faculty Support–LEA leadership, site principal and participating teachers committed to project

- All students member of cohort–each participating student is enrolled in the appropriate companion courses during the same semester (beginning school year 2008–2009)

- Administration permits, participating teachers agree, to off-site training (up to 3 days) during school year (substitutes, travel, and subsistence to be covered by grant). Teachers agree to meet regularly on site in the development and application of instructional materials and activities.

Project Advisory Board Composition

- Dr. Aaron Clark–Project Director, NCSU
- Dr. Jeremy Ernst–Curriculum Development Coordinator, NCSU
- Janice Johnson, Programs Director, Centers for Quality Teaching and Learning
- Mathematics Specialist–Debra Kinsey, NCDPI
- Eleanor Hasse, Science Specialist, NCDPI
- Tom Shown, Technology Specialist, NCDPI
- Robert White, CTE Director, Guilford County Schools
- Sandra Meads, CTE Director, Perquimans County Schools
- James R. Bunch, Principal, Perquimans County Schools
- Pam Bello, CTE Director, Vance County Schools
- Principal, TBD, Northern Vance High School