VisTE: Visualization for Technology Education; An Outreach Program for Engineering Graphics Education

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Abstract

Visualization in Technology Education (VisTE) is a standards-based initiative designed to promote the use of graphic visualization tools among students in grades 8-12. By using simple and complex visualization tools, students can conduct research, analyze phenomena, problem solve and communicate major topics identified in the Standards for Technology Literacy (STL) as well as topics aligned with national science and mathematics standards. Therefore, in the future, students will come into engineering and technology programs at the post secondary level already having these basic visual skill. This paper will discuss this new national project and how its approach to technogical and visual literacy can impact instructional approaches to engineering design graphics at the secondary and post-secondary levels.

Introduction

The NSF VisTE (Visualization in Technology Education) Project is designed to promote the use of higher order thinking and communication skills and the understanding of technology, mathematics, and science through the use of graphic visualization tools. High school students using simple and complex visualization tools, conduct research, analyze, and solve problems around a range of technology and science topics. The twelve units being developed reflect the newly developed Standards for Technological Literacy (STL). [1] These standards, developed in conjunction with the National Science Foundation and NASA have as their goal to provide a framework for improving technological literacy in grades K through 12 and, therefore, provide better prepared students for post-secondary engineering and technology programs. Developed in partnership with North Carolina State University, the Southern Regional Education Board (SREB), and the North Carolina Department of Education, these units are being piloted in SREB "High Schools That Work" sites [2] that were selected to provide a diverse population for evaluation. The project's processes and outcomes are being assessed by RTI International.

For a variety of reasons, powerful graphic tools outside of mechanical and architectural CAD are not commonly employed in the technology education classroom. To address this need, the VisTE Project has designed units that direct students toward developing data driven and conceptually driven graphic models directly related to technology. Data driven models (even simple ones like graphs and charts) can help elucidate relationships not easily seen from raw numbers or written reports. Data driven models also argue for and enforce the use of mathematics and scientific data upon which most technology is founded. Conceptual graphic models (such as the flow of fluids across a foil, visualization of scientific and technological phenomena, artifacts or structure) facilitate the demonstration of technological and scientific concepts and principles, which would be difficult or impossible to replicate with text, mathematical or spatial models.

Employing these visualization tools in the technology classroom helps students develop better problem solving, analytical, and communication skills. It also promotes a deeper appreciation and understanding of technology's most important and fundamental concepts and their related scientific and mathematical principles. These skills are critical to preparing students to enter post-secondary engineering and technology programs. While the current science and mathematics courses provide much of the raw knowledge needed for these curricula, technology courses can provide the synthetic experience of "putting it all together." The graphics approach of the VisTE units is a powerful method for providing a mechanism for this synthesis.

Technological and Visual Literacy

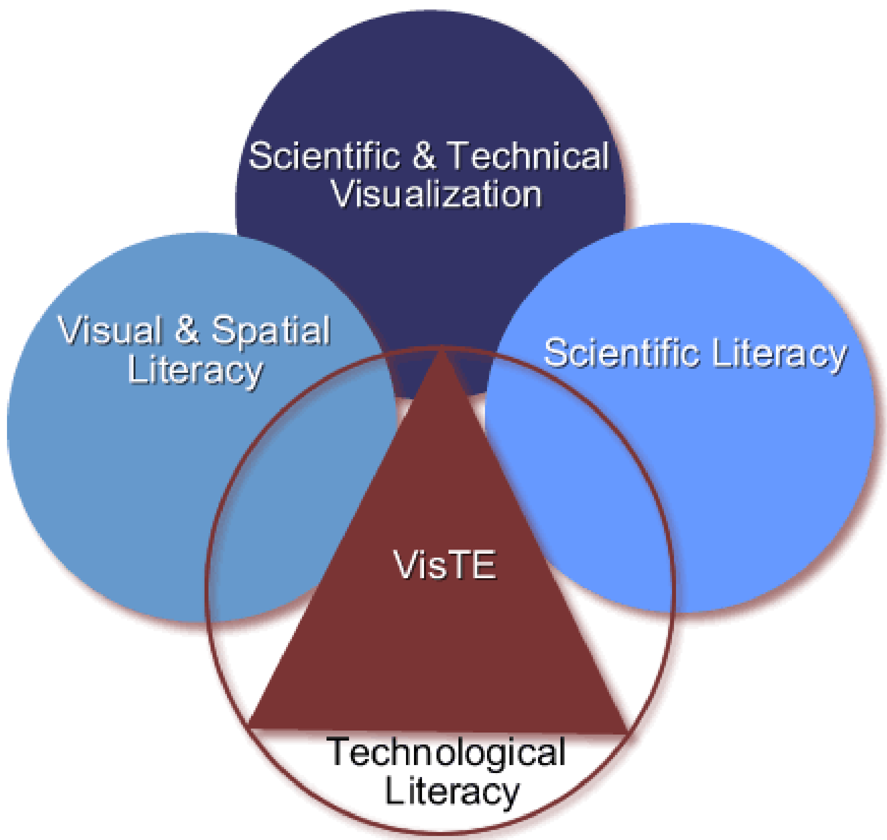

Figure 1 – Conceptual Framework of the VisTE project

The VisTE project has as its primary goal to promote technological literacy (Figure 1). Being technologically literate implies proficiency and knowledge. [3] That is, a literate student can produce a technological artifact, defend his or her solution in terms of efficiency, cost, functionality, etc. and reflect on the larger impact of this technological solution in terms of meeting societal needs. This project's approach to technological literacy is through the area of communications technology and as such, has the development of visual literacy as a primary goal. Visual literacy implies the ability to both produce visual materials and to interpret/use already produced visuals. To do so, one needs to have the knowledge of both the semantic and syntactic underpinnings of the graphics in question. [4]

Given the exceptionally broad application of graphic communication, the type, or genre, of graphics needs to be narrowed to more realistic boundaries. A more narrow definition of the genre of graphics is also needed because a workable definition of technological literacy means employing knowledge to reason, understand, or solve problems within a well-defined context [5] and only then be able to generalize that knowledge and ability to other contexts. [6] The VisTE project focuses on the technology of scientific and technical visualizations used to convey information about science and technology. In doing so, students engage in the selection and use of graphic tools and techniques that will produce visualizations that communicate about specific technological and scientific concepts. The use of these tools not only develops graphic knowledge that can extend in to other areas, but also develops technological and scientific knowledge that can be used in future technology and engineering curricula.

The VisTE goals for visual literacy fit squarely within the current definitions of general technological literacy as defined by technology and science education communities, both in the United States and abroad. [1, 7-10 11] Some of the overlap between the scientific and technological fields comes from an understanding that in modern society, it is difficult to draw clean lines between science and technology and the role that design plays in both areas. [12-14] Both technology and science employ creative problem-solving approaches to answer questions/problems that arise, with science typically employing a more analytic approach (e.g., investigating the nature of what exists) while technologists a more constructive approach (e.g., creating that which does not yet exist).

Technological design is a necessary part of the scientific endeavor; in that technology is employed to support scientific tasks such as observation and measurement and that scientific discovery leads to the development of new technologies. Conversely, scientific understanding can both be made possible by technological devices and can arise from the evolution of understanding of the conceptual basis of existing technologies. Related to this, technological design problems often employ a scientific approach of experimental variation, measurement and quantification in order to refine potential design solutions while scientists will employ open-ended brainstorming techniques to break through conceptual roadblocks. Graphics communication can be a unifying factor when looking at the intersection of science, technology, and design. It plays a communication role in all three and can act as a universal medium for the movement of ideas and concepts between them.

Visual Literacy for Engineering and Technology

Graphic communication has a long history in technology and engineering education, with graphics being employed both as the final outcome and intermediate stage for numerous technological design activities. [15, 16] Studies of how graphics are used in professional engineering and design practice indicate the importance of this means of communication. [17] Graphic communication in this setting includes graphics produced not only as a means of communication to oneself in the course of working through design issues, but as a central medium of communication and negotiation with other members of the design team. This approach is not unique to design and engineering applications, either. Similar patterns are seen in science fields where scientists and technologists use graphics for both personal meaning making and communication of findings and proposed hypotheses to others.

Visual expression is a key cognitive activity as both students and professionals move through design problems. [18] These graphic expressions can be used to manage and represent spatial characteristics of the final design or more abstract notions. While we commonly think of drafting or CAD technologies being used to document the two and three-dimensional forms of manufactured products, much less formal graphics are used earlier in the design process. Less formal graphics are used to represent multiple potential solutions and to problem-solve spatial arrangement and form issues. Similarly, graphics can be a tool to represent non-spatial ideas and information in a way that usefully summarizes or synthesizes the information. One measure of the competence of a designer is their ability to make use of such graphic tools in the course of the design process. [19]

These uses of graphics provide support for constructivist approaches to education where students are encouraged to search and evaluate their own tentative solutions, making use of multiple representations in multiple media. [20] Beyond this core foundation is the goal of moving students to a higher level of literacy where they can apply the knowledge of scientific and technical visualization to critically interpret graphics by using their knowledge to analyze the strengths and weaknesses of a graphics used for the purposes of communication. Here, the design problem and the construction of knowledge now centers on the graphic communication itself.

Visual Design Projects

What follows are examples from three VisTE units that are currently under development. Each unit embodies the overall goal of technological literacy through explorations in graphic communications design. Each unit is centered on one of the technology concentration areas identified in the Standards for Technological Literacy. In addition, the Standards provide an overall structure for the units, making sure that each unit provides projects that emphasize, technology fundamentals, technology and society, and design and technology (Figure 2). The introductory level activities provide background in the technology focus area (e.g., bioprocessing) and the graphic communication technologies that are going to be employed. The intermediate and advanced level projects provide for more open-ended design experiences. The technology and society projects can be explored at both introductory and intermediate levels and then expanded on in advanced projects.

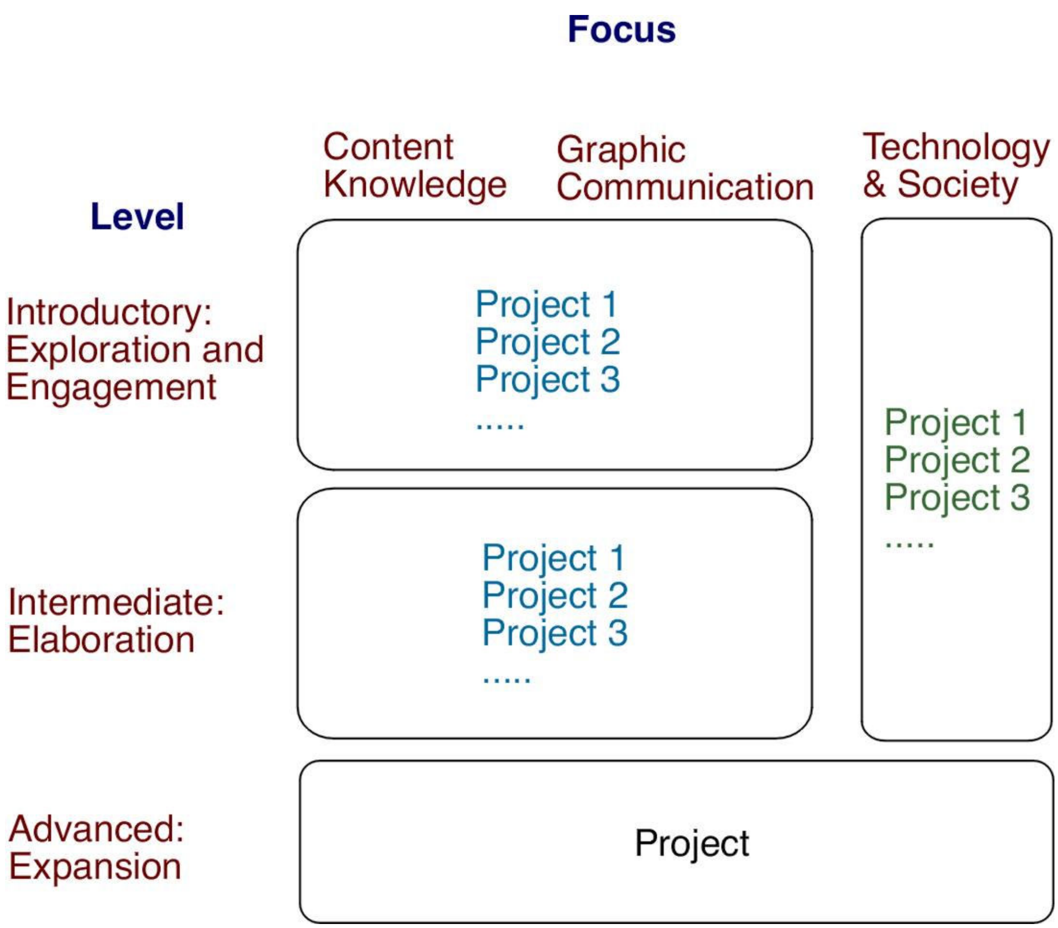

Figure 2. Project organization within each Unit.

Prosthetics Unit

This unit is focused on medical technologies. Students learn about the history of prosthetics and explore and solve some of the design problems associated with prosthetics construction. Students also explore the societal implications of providing support for persons with disabilities as well as the engineering and design involved in creating that support.

In the second project of the unit, “Artificial Joints & Limbs,” Students examines anatomy and physiology in preparation for designing an internal prosthesis (Figure 3). A variety of materials can be used for this project in which students will both create conceptual graphics and build a physical model of the knee joint.

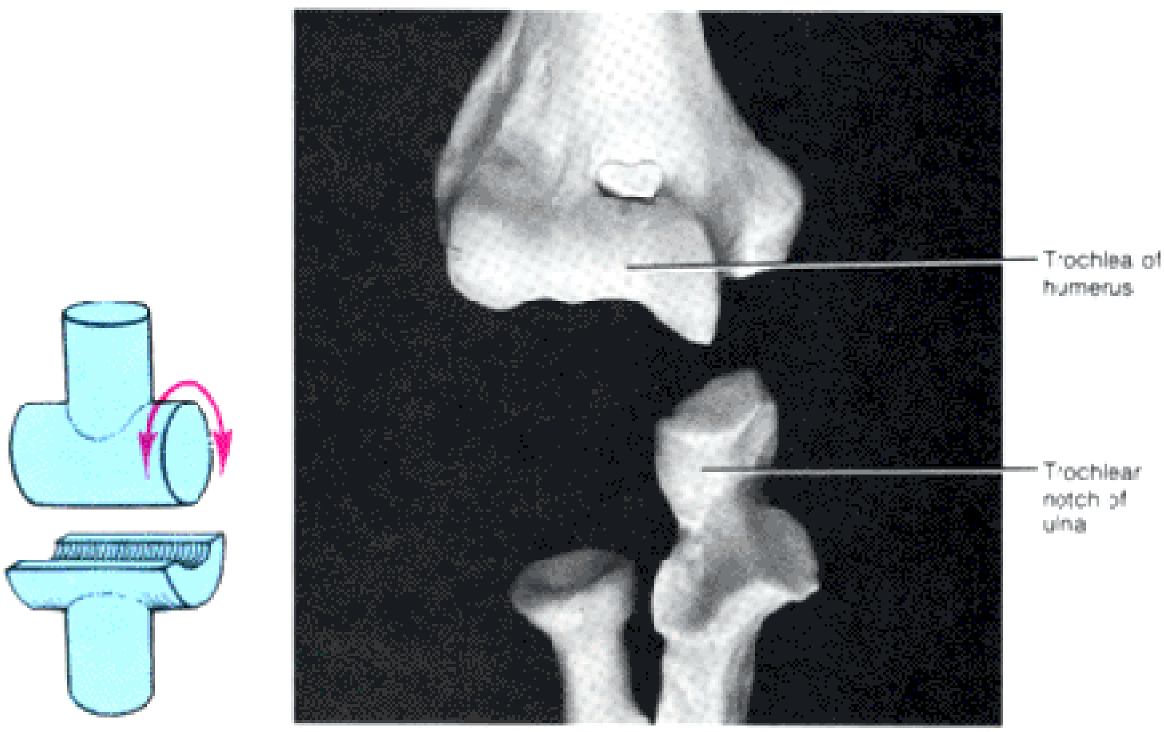

Figure 3. A diagram and photo of an elbow joint. Adopted from Tortora [21]

Bioprocessing Unit

This unit focuses on agricultural and related biotechnologies. Students learn about the fundamentals of bioprocessing technology and how this technology is used to produce and manufacture many different products for the industrial, pharmaceutical, food, and environmental sectors.

In the second project, "The Bioreactor," students take a detailed look at the bioreactor as the main tool of bioprocessing technology. Using multiple resources, students will create a two-dimensional drawing of a bioreactor (see Figure 4) as well as a functioning physical model. In doing so, students will review different types of bioreactors and their uses. They will also identify and describe the main bioreactor components as well as their functions.

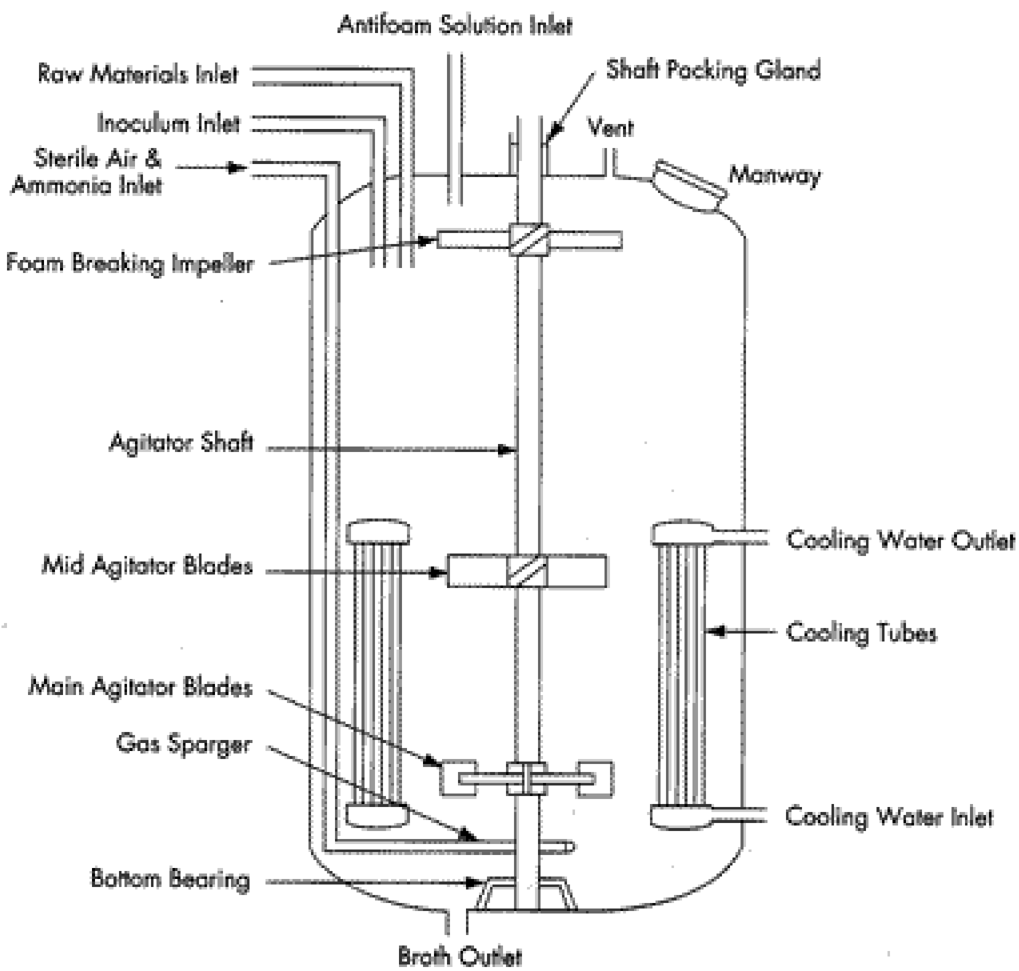

Figure 4. A schematic diagram of a stirred tank bioreactor. Adopted from NCBC [22]

Medical Pump Technology Unit

In this unit, students explore 3D computer animation tools and have the opportunity to use object oriented graphics software to represent different types of medical pump technologies. The material also helps students develop an understanding of the mathematical and geometric basis for 3D modeling and animation.

In the first project, students examine differences between basic types of pumps used in medical devices. In particular, they explore piston (syringe) pumps, diaphragm pumps and peristaltic pumps that use both rotary and linear motion. As part of this project, they build a 3D model of one type of medical pump (Figure 5). In a later project, they animate the model to demonstrate its functionality.

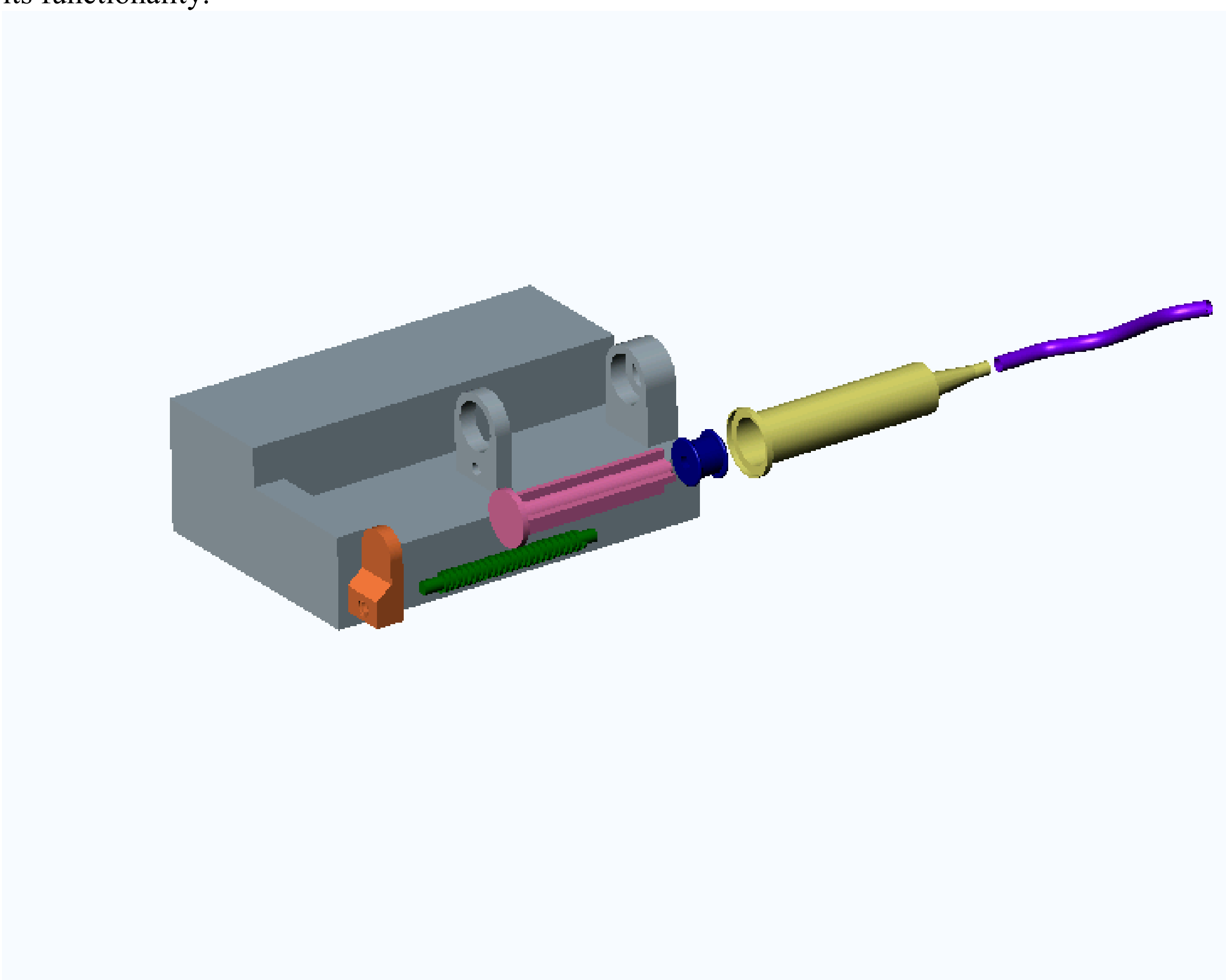

Figure 5. Exploded view of a syringe pump model.

Conclusion

At the end of three years, the project's products and outcomes will include 12 standards-based units (in print and CD format) written for a diverse audience of high school students. This process will include national dissemination of the units, teacher training workshops, local and national presentations, and a formal evaluation of the project's process and student outcomes.

Guided by national standards in technology and science education, the VisTE project takes a unique approach to strengthening the role of graphics in the secondary curriculum. This approach also provides support for technology education as a means to expanding the pre-engineering/technology curricula by providing synthetic design activities that both enhance the knowledge of advanced graphic tools and explore science and technology topics in a new, innovative way; motivating students who have been otherwise turned off by traditional text-based approaches of instruction. Enhanced technological and scientific literacy is crucial to the future health of engineering and technology professions. There is no sole strategy to improve the numbers and quality of students matriculating into these post-secondary programs, but VisTE provides yet another way to help support this goal. VisTE also provides numerous examples of the power of graphics in instruction and future professional activities.

Acknowledgements

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Biography

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Dr. Wiebe is an Associate Professor in the Graphic Communications Program at NC State University. He has authored or co-authored four texts on technical graphics and has been involved in Computer-Aided Design (CAD)/3-D modeling development and use since 1986. During the past ten years, he has worked on the integration of scientific visualization concepts and techniques into both secondary and post-secondary education. Dr. Wiebe has been a member of the EDG Division of ASEE since 1989.

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