Team Teaching with Academic Core Curricula Teachers: Using Aviation Concepts

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Beginning in the 1970s and throughout the 80s and 90s, schools were confronted with education reform initiatives that introduced many ideas. These included outcome-based education, which was followed in turn by performance-based education. However, problems developed along the way when some individual teachers inserted their own agendas and applied their own definitions to outcome-based and performance-based education (Towers, 1994; Manno, 1995; Schrag, 1995; Eakman, 1996). Standard definitions and methods were lost in the confusion and these programs became open to just about any "touchy-feely" notion that appealed to the individual teacher. Ponnuru wrote that outcome-based education "has little to do with raising academic standards. Instead, it replaces existing standards with vague, often psychotherapeutic goals. These new goals become the criteria for assessing students, teachers, and schools" (1994, p. 46). Much progress has been made in the past decade to clarify standards, but the conversations concerning reform and the debates about how reform should happen, continue.

Out of the ashes of failures, and especially as a result of the efforts of those who recognized the problems and worked to correct them, came programs such as School-to-Work and Career Pathways and the development of new courses in vocational high schools and tech-prep schools. "Shop" and vocational education programs began to take on a new appearance under the new name of technology education. Yet in spite of government intervention and the redefining of technology education, problems and misconceptions about our field persist. Some administrators and academic core curricula teachers still look down upon technology education and industrial arts courses as non-academic

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classes that serve only to fill the school time of those students who are not planning for a post-secondary education. Even from within the ranks of technology education, we continue the struggle for the "legitimization of technology education as a school subject," (Lewis, 2004). Students who are not excited about school are still falling through the cracks while the "brighter" students graduate from high school with theoretical knowledge, well-prepared for post-secondary education programs, but severely lacking in the ability to apply what they have learned to the everyday life experience of employment.

The solution to these difficulties lies within technology education itself. Technology education holds the potential for teaching all students the skills of problem solving, and technology education teachers should be emerging more and more as a vital part of the academic core teaching team.

Premise

Technology education teachers today have at their disposal the skills, opportunity, experience, ingenuity, expertise, equipment, and environment to greatly improve students' ability to learn and apply the knowledge they have gained in their academic programs. This paper is based on the following four propositions:

1. Technology education is the logical system for providing an effective performance-based education that prepares the student for his or her immediate future, whether it be a post secondary education institution or the job market.
2. Technology education teachers are the key to helping students make the connections between their academic core course material and the real world. Technology educators can accomplish much by aligning themselves with academic core teachers in a team-teaching environment, benefiting both the academic core and technology education programs.
3. Aviation concepts and projects can provide the catalyst and the vehicle by which students can discover the relevancy of their entire academic core curriculum. Even core curricula teachers who have had no aviation

education or training can incorporate aviation concepts to motivate students to learn academic core material.

4. By incorporating aviation concepts, students can grasp the importance of learning core subjects in high school and at the same time learn the empirical knowledge and skills that technology education offers for facing life in the real world.

Aviation training, like many critical professions, was an outcome-based education before outcome-based education became a philosophical idea. Many schools geared towards industry, particularly charter schools and magnet schools, have adopted educational materials with a focus on aviation. On January 8, 2002, President George W. Bush signed the "No Child Left Behind Act of 2001" (NLBA) into law. The new law represents the President's education reform plan and "contains the most sweeping changes to the Elementary and Secondary Education Act since it was enacted in 1965," according to the National Aeronautics and Space Administration (NASA, 2002, p. 5). Since President Bush signed the NLBA into law, aviation has begun to play an increasing role in K-12 education in the United States. Both NASA and the Federal Aviation Administration, along with several universities, have taken a proactive part in producing aviation related materials tailored to all grade levels. While most schools are not ready or cannot afford to make a drastic shift in their curriculum, technology education teachers may nonetheless work with academic teachers to link aviation concepts to their school's curriculum.

Team Teaching

Historically, teachers have operated in isolation when teaching their classes, acting as the sole disseminators of information the students must learn in order to pass their particular class (Heller, 1967; Buckley, 2000). For most high school students, their school day is divided into equal, seemingly unrelated time periods with no structure to assist them in making relevant connections between disparate courses. Some educators question the wisdom of this approach. The Northern Nevada Writing Project Teacher-Researcher Group wrote, "Interdisciplinary classes help students see the relationships between disciplines, assuring that they make connections they would otherwise be left to make on their own" (1996, p. 7). When that interdisciplinary relationship is formed between academic core and technology education teachers, the combination packs a great potential for learning. When a technology education teacher joins forces with an academic core teacher, the students reap the benefit of gaining empirical knowledge and skills not usually acquired within the confines of the traditional teacher-centered classroom. By completing projects and design activities, routinely offered in the technology education lab, students engage in critical thinking and gain transferable and empirical knowledge and skills (Cotton, 2002; Helm & Beneke, 2003; Johnson & Chung, 1999). Furthermore, through the active learning strategies of the technology education classroom, the student is given more ownership of his or her own learning and may develop a greater desire to participate in the learning process. The students' motivation to learn can thus be transferred from an extrinsic source to an intrinsic source (Brewer & Burgess, 2005).

There are several models for structuring team teaching. Goetz (2000) lists six styles: traditional team teaching, parallel instruction, differentiated split class, monitoring teacher, collaborative teaching, and complimentary team teaching. The first four styles are similar in that they each share or divide responsibilities for teaching the same material to the same class during the same time period. The last two, collaborative teaching and complimentary teaching, follow a somewhat different format.

In collaborative teaching two teachers work together preparing for the same lesson but then deliver their material to the students in a two-way discussion forum. A possible drawback of the collaborative teaching approach is that it has the potential to confuse students if two teachers present differing viewpoints on a particular subject. On the other hand, exposing students to a variety of viewpoints may help them analyze information and encourage them to make their own informed decisions, rather than robotically swallow opinions and thought processes spoon-fed them by a teacher or from a textbook.

In complimentary team teaching, one teacher delivers the core material in his or her lecture class, and then the material is followed-up by another teacher in another class, usually incorporating a different style of learning. One might think of this teaching method as relay or tag-team teaching. Of Goetz's six styles, complimentary team teaching provides the format most suitable for bringing technology education into the academic core curricula arena.

Complimentary team teaching can be an exciting and fruitful style of teaching for both the technology education and core curriculum teachers as well as for their students. It is not a teaching style that results in conflicting information from two different teachers, but, rather, when carefully orchestrated, provides a supportive, reinforcing, and encouraging learning environment for students. In complimentary team teaching, the academic core and technology education teacher work together as equals. In no sense does the technology teacher become a teacher's aid to the core teacher. Rather, each teacher reinforces what the other has taught. The core teacher provides the lecture, theory, and, together with the technology teacher, designs the student assignments. The technology education teacher provides the laboratory, skills, and expertise to assist the students in building working models for experiments and simulations that verify the theoretical results arrived at in the core lecture class. Simply put, the core teacher explains that 2 + 2 = 4, and the technology education teacher shows the student how to successfully demonstrate that 2 + 2 = 4. The teachers work as a team, moving toward the same conclusion, much as an engineer, a technologist, and a technician do in an industrial environment.

In complimentary team teaching, the theoretical may be introduced first and then applied in the laboratory; however, the reverse can accomplish the same purpose. Another approach is to first present the students with the challenge of a life-situation to solve, and then have them examine the theoretical side of the experience in an academic core class such as math, science, or physics. In this case the lesson begins in the technology education class and is followed up by lecture in the academic core classroom. For some students, particularly hands-on learners, this approach may be preferable.

Complimentary team teaching allows the teachers to appeal to many different learning styles. Students have more than one chance to understand the material. They learn about a topic from two different teachers and in the technology laboratory, are free to apply a variety of learning styles as they work to complete the practical assignments.

Regardless of whether the theoretical learning precedes the applied learning or vice versa, the technology education class provides a learning lab for the academic core instruction. In the lab students learn skills in the use of tools, design, construction, and problem solving. Students immediately apply the theories presented in the core class to the related projects in the technology education class.

The model of complimentary team teaching can involve a variety of subject area combinations. In one case where complimentary team teaching has been practiced, mathematical concepts were introduced in a math class and then the math concepts were applied in a chemistry class (Goetz, 2000). Mulholland described how a team of teachers "developed team-teaching models that would enhance learning environments by integrating reading-, writing-, and math-skills development" (2005, p. 16). An unexpected team teaching arrangement was used to combine lessons in English and woodshop. After reading *The Diary of Anne Frank* in their language arts class, the students drew blueprints and then built models of an Amsterdam house—a project which also linked the lesson with their math standards (Mulholland, 2005). In his discussion about the inclusion of engineering design as content in secondary education, Lewis writes that an "option might be to adopt a collaborative approach to design, where technology teachers team with mathematics and science teachers, and with practicing engineers, in the teaching of design. This strategy would allow both analytic and conceptual aspects of design to be realized" (2005, p. 50).

Not all teachers may buy into this philosophy of team teaching. Some faculty members may not want to make changes from their routine. Some may recognize that they have mastered a successful method of teaching and find no advantage to altering it. They may prefer to stick with the tried and true. Heller (1967) offers a "note of warning:" "Not all teachers can be, nor want to be, team teachers. They are successful in their own right, and they are not convinced that a change is best for them. Perhaps they are correct, and their wishes should be respected. If team teaching stresses individualization, it is ridiculous to contradict this emphasis by trying to force every teacher and student into its mold" (p. 13).

Team teaching initially requires some extra planning time. However, for those teachers who are interested in initiating team teaching in their schools, there are ways to begin with a minimum of disruption to established school schedules or existing lesson plans. For example, a technology teacher might pair up informally with a mathematics teacher and, by designing activities for the technology lab that connect to the math teacher's lesson topics, provide students with relevant applications of concepts covered in their mathematics class. Once such a cooperative relationship between teachers is established and flowing smoothly, other teachers as well as administrators may see that complimentary team teaching provides advantages both to students and teachers alike.

Using Aviation Concepts

Many areas of technology education can be successfully integrated with academic core subjects to serve as team teaching arenas. Building construction or automotive concepts would certainly serve well. So why use aviation? One reason is that teaching with aviation concepts captures the imaginations of children of all ages, and constructing aviation projects magnifies their interest and enthusiasm for learning. Magnet schools across the United States are experiencing success and growth using an aviation theme. In 2005 the Federal Aviation Administration conducted the seventh bi-annual National Aviation Magnet Schools Survey, which identified 67 aviation magnet school programs. Since 1985 the Magnet Schools of America Association has identified 71 different magnet themes, of which aviation and aerospace is one of the fastest growing themes (Federal Aviation Administration, 2005).

In addition to sparking student interest, aviation concepts serve as excellent sources of material for mastering the objectives listed by the Standards for Technological Literacy. Under "The Nature of Technology" standard 2 states, "Students will develop an understanding of the core concepts of technology"

(International Technology Education Association, 2000, p. 32). Aviation is an excellent vehicle for communicating the core concepts of technology: During the process of flight the aviator and machine must work as one with the aviator relying on appropriate and accurate feedback from the controls. In flight, an airplane's various systems must come together and make the necessary optimizations and appropriate trade-offs to fulfill the requirements of the physical laws that enable the plane to overcome the force of gravity.

Technology standard 3 states, "Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study" (ITEA, 2000, p. 44). Aviation provides a comprehensive and broad range of technologies that bring together various education disciplines. The most obvious disciplines related to aviation are math, science, and physics. However, safety in aviation depends upon the aviator also being proficient in speaking, reading, and writing skills. An aviator needs to be a good communicator. He or she must be a person of integrity who is dependable, ethical, and responsible.

Team Teaching with Math and Aviation

Uniting a technology education teacher with an academic core mathematics teacher and using aviation as a theme seems a logical place to start a complimentary team teaching partnership. Without math there would be no aviation and no space technology. Correspondingly, without aviation science, there are math concepts whose relevance might not yet be recognized. Many concepts proven through the experiments and empirical knowledge gained through the space program would still be merely theories in books had it not been for aviation science. Students can profit from investigating and understanding this dynamic interrelationship.

Many technology education teachers are familiar with the Wright Brothers Design Challenge kit available from KELVIN® (Kelvin, 2005). With these kits, students design and build Styrofoam airplanes out of ordinary Styrofoam food trays and specialty parts that can be purchased from KELVIN®. After completing their models, students then put the airplanes to the ultimate test of flight.

Outlined below are some possible activities and experiments that can be done with the student-constructed Styrofoam airplane as its flight worthiness is tested. These activities explore and test both the mathematical as well as the physical concepts that govern flight. The projects provide practical applications for the theoretical knowledge students have gained in their math classes and confront the students with the real-world technological challenges of aviation.

One important consideration when designing an aircraft for flight is the effect of weight and balance on the airplane. A student can explore the consequences of different weight loads placed in different locations within the Styrofoam airplane by cutting a cabin area from the model's fuselage and placing weights at different longitudinal locations. While students may initially test their crafts resulting flight capabilities through trial and error, with the help of their math teacher, they can investigate mathematical methods for determining optimal weight distributions.

Even if the weight is located properly in the airplane, there is a maximum weight that an airplane can carry. If the force of lift does not exceed the force of the gravity on the weight, the airplane will not fly. Wing area and wing shape—along with the speed of the wing through the air, the angle of attack of the airflow, and the density of the air—are the five factors that affect lift. By making adjustments to their airplanes wings, the students can demonstrate the effects of simple wing changes on their airplanes' flight. Students can learn about the mathematical side of the coefficient of lift by accessing the NASA website, www.grc.nasa.gov/WWW/K-12/airplane/short.html.

In the process of testing their airplanes, students might begin to wonder "Do I have a motor powerful enough to pull this weight fast enough to fly?" "Is my propeller big enough?" "What will happen if I install a bigger motor or a bigger propeller on the plane?" By measuring the diameter of the propeller and determining the speed of the motor from the manufacturer's specifications, the students can compute mathematically just how fast the tips of the propeller are traveling. They can explore mathematically how changes in propeller and motor size will alter the spin and speed of the propeller.

The third factor of lift, the speed of the wing through the air, also spawns an important question: "How fast does my airplane fly?" To explore the answer to this question, students can use empirical measurements taken in the technology laboratory and apply them in the mathematical formula for speed. The student can record the airplane's time in flight and measure its distance flown and then, knowing distance and time, use the mathematical relationship between distance, rate and time to determine how fast his or her airplane is flying. Students can experiment with alterations in their airplane models to see how speed is affected by changes in aircraft design.

Discussions of wing aspect ratio can assist students in recognizing the meaning and the significance of the lessons on ratios that they study in math class. Airplanes with two different wing designs, each having the same surface area but differing aspect ratios, require different air speeds to maintain flight. The technology teacher can guide the students in experiments that use two wing designs that differ in aspect ratio but that maintain the same surface area and cross sectional shape. Using the methods for determining airplane speed, the students can explore the minimum speed requirements that airplanes with different wing aspect ratios require to remain aloft or airborne.

During the course of these experiments there is a very real possibility that some airplanes may crash and need repairs. A few crashes will provide concrete motivation for students to get the numbers correct in the math class, or it's back to the "drawing board" in the technology lab.

Conclusions and Implications

Lewis acknowledges that when students compete in engineering contests to build the longest or strongest bridge or to construct the highest tower "often the teaching episode ends when the winner is identified, without students gaining understanding of the reasons behind the success or failure of their attempts" (2005, p. 50). In industry, the structural testing and resulting failure of products is called "destructive testing," meaning the product is of no more use for further testing other than analyzing the points of failure. However, the Styrofoam airplanes' tests described above and the aircrafts' performances in the various suggested experiments are in a sense "non-destructive" testing. With correct mathematical computations, each test can be completed without destroying a student's model. The "non-destructive" testing permits a student to experiment further and to continue to learn using the same self-constructed learning platform – the airplane. The empirical knowledge gained through the Styrofoam aircraft design activity can increase students' understanding of the relevance of mathematics, improve students' problem solving ability, and enhance the students' learning environment.

Standard 9 of the *Standards for Technological Literacy* focuses on the understanding of engineering design. "One of the final steps in the engineering design process is to build or construct the actual product or system in order to determine if it works" (International Technology Education Association, 2000, p. 99). This is an equally important final step in the learning process of high school students but is one which is often disregarded or over-looked and omitted in academic core classes. Successful pragmatic outcomes should complete and underscore the abstract theoretical facts the students have mastered in their academic core classes. With a technology education teacher team teaching with an academic core class teacher, the learning experience can include this final, all-important, hands-on step that completes the study topic and brings it to a logical conclusion.

Aviation is a subject which seems to appeal to girls and boys of all ages. One evening, while flipping through television channels, I happened to stop on a program in which children were individually being asked the question, "What do you think heaven will be like?" Each was asked the question privately; each without knowing how another child responded. One girl replied that the flowers would never die and would always smell wonderful. A boy imagined out loud that there would be lots of animals and he would be able to ride the elephants and tigers. Another boy was content with just riding horses all the time. Most had different answers; girls responding with "typical girl answers" and boys giving "typical boy answers" – except in one area. Only one picture of heaven was imagined by several of the children—boys and girls alike: "We'll be able to *fly* all over."

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