Book Review

Frye, E. (1997). *Engineering problem solving for mathematics, science, and technology education*. Hanover, NH: Trustees of Dartmouth College. $15.00 (spiral-bound paper paperback), 135 pp.

Reviewed by Vincent Childress

Engineering Problem Solving for Mathematics, Science, and Technology Education appeals to the reader on several levels. It is a guide for teachers, including technology teachers, who want their students to learn authentic strategies for solving real-life, discipline-based problems. It focuses on an engineering problem solving method, and it touches on interdisciplinary team management, instructional management, and student assessment. More importantly, this resource provides practical examples of how teachers have used the method successfully and why industry leaders believe the method is relevant to the skills they require on the job. *Engineering Problem Solving for Mathematics, Science, and Technology Education* will provide the technology teacher educator with a resource for problem solving instruction in both technical and methods classes. At the same time, the book is unsettling to the technology educator because it omits some concepts that are fundamental to the field, and it illustrates the importance of issues that technology education must face at both the national and grassroots levels.

Engineering Problem Solving for Mathematics, Science, and Technology Education was written by Ellen Frye and was an outgrowth of a project at the Thayer School of Engineering at Dartmouth College. John Collier, D. E., a professor in the School of Engineering, incorporated an engineering problem solving method into a hands-on, introductory course. The practical nature of the course made it very popular. The engineering school began offering workshops to mathematics and science teachers, and with major funding from the John Brown Cook Foundation and others, this service grew to become the Dartmouth Project for Teaching Engineering Problem Solving. The method of instruction taught in the workshops is so popular with mathematics and science teachers that the book was written for those who are not able to attend the workshops.

The book is well-written and easy to understand. Frye has avoided using technical jargon, and her prose flow smoothly for the reader. It is well organized, starting first with an engineering problem solving cycle. It identifies and explains the process that engineers use to solve a host of practical problems. The method is a step-by-step process, and the reader is encouraged to demonstrate the steps of the process to students. After providing detailed

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examples of researching and documenting each step, the teacher becomes the facilitator, and students become the engineers who solve problems that they identify.

Johnson (1994, pp. 27-26) cited criticism on the use of stage models for solving problems where the model is over simplified and linear. He cited studies that provided strategies that should be taught to students for problem solving. The engineering problem solving cycle in Frye's book is depicted as a spiral process with complex activities within most of the steps of the process. While student intuition and metacognition are inherently important to develop in this problem solving process, each decision that a team of students makes is intended to be based on documented, quantitative analyses. The model appears to include those strategies that Johnson identifies, while at the same time providing structure that is designed to help the engineer create a structured problem from an ill-structured problem. It is both divergent and convergent, but the greatest emphasis is on the convergence of the process (See Shaw & Reeves, 1978; Dugger, 1994, p. 20).

Frye provides excellent examples of engineering problem solving that illustrate how engineers use a matrix that rates possible solutions in relation to the specifications that the engineers determined earlier in the process. Once each idea is researched, the engineers apply ratings to each. The top scoring idea is retained and the others are dropped. The team proceeds to take the chosen idea and define it further into subordinate alternatives which are again applied to the matrix and rated. The process is logical and iterative, and it spirals toward a workable design. Ideally, once the team of engineers believes it has a workable solution, they will implement it as a prototype.

Frye provides useful advice for the classroom teacher that is based on the experiences of the mathematics and science teachers that adapted the method to their classrooms. This experience is noteworthy because it tends to validate the experience of technology education teachers in curriculum integration projects such as the Technology, Science, Mathematics Integration Project at Virginia Tech (See Childress, LaPorte & Sanders, 1994, p.34). Frye includes a wide range of ideas teachers used to make room for the innovative method in the curriculum. Teachers are trying to use interdisciplinary teams without students in common, teach the process for the first 10 minutes of class each day, or have students work on problems after school or for homework. It appears that the struggle to implement meaningful reform is a problem experienced across the curriculum.

At the Thayer School of Engineering, Collier noticed that the engineering curriculum was so theoretical that some students were less motivated than they would have been if they had the opportunity to work on real-life engineering. He developed the aforementioned course so students could employ engineering problem solving in a fun and relevant way. The students proceed from a theoretical phase to a hands-on phase in which real product prototypes are developed. It is interesting to note the similarity between Collier's motivation to include hands-on instruction in the Thayer School's engineering program and Calvin Woodward's motivation to open the Manual Training High School of

Washington University in 1879. Woodward wanted aspiring engineering students to benefit from practical experience (Coates, 1923, p. 10).

Teaching the engineering process is fundamental to technology education, and doing real technology is also fundamental. One of the criteria that is applied to engineered technological solutions is that they work. In technology education, part of the learning process is engineering these simulated or working prototypes. Perhaps through no fault of the Dartmouth Project or Frye, the book provides little evidence that the participating mathematics and science teachers are really getting their students to implement authentic technological solutions. Some fully implemented technological solutions are presented, but Frye describes only two scenarios in which the technology education teacher participates. In one example, the technology education teacher is the science class's consultant on how to build prototypes, and in the other he or she is team teaching science class with the science teacher. It is good to know there exists the need for technological literacy, yet it is troubling to realize that relatively few colleagues and students can capitalize on the importance of technology education.

If technology educators at all levels do not quickly secure a recognizable position in technological education, then mathematics and science education will teach technology without them. Frye includes a section in the book that provides problem solving ideas that do not require tools. This would not be considered unusual except for the fact that the focus is on engineering problem solving and is inspired by the notion that it is important to proceed beyond the theoretical.

For the technology teacher, the book is useful and compelling. The problem solving method represents a refreshing opportunity to balance the need to address both cognitive development and authentic instruction. Reading this book tends to validate recent experience in technology curriculum innovation and reform. And, it certainly reminds technology education of the need to continue positioning itself and develop working relationships with wonderfully innovative educators such as those who are so well described in *Engineering Problem Solving for Mathematics, Science, and Technology Education,* a practical resource for the technology teacher who accepts the challenge of authentic instruction.

References

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