Technology Education in the American Elementary School

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This article communicates the importance of elementary school technology education (ESTE), describes its roots, its current status, and historical and ongoing research and development. In today's technology-based society it is imperative for all students to be technologically literate (Dyrenfurth & Kozak, 1991; Technology for All Americans Project [TAAP], 1996; Raizen, Sellwood, Todd, & Vickers, 1995). Many national reports on the status of science and technology education (TE) in the United States have called upon schools to provide increased experiences with technology and to focus on technological literacy (see, for example, American Association for the Advancement of Science [AAAS], 1989; Johnson, 1989; Technology Education Advisory Committee [TEAC], 1988; TAAP, 1996). In fact, Strand #8 in the National Council for the Social Studies Standards (1994) specifically calls for an understanding of technology, not just computers.

Technological literacy, similar to other literacy efforts, requires knowledge and practice acquired over time. A one-semester course is hardly adequate to develop language literacy, numeracy (Paulos, 1990), or technological literacy (TAAP, 1996). Indeed, understanding technology and its social and environmental impacts and consequences should start as soon as students begin attending school. All students, regardless of socioeconomic level, race, ethnic background, community, disability, or career aspiration, need to be able to cope with change, identify and solve problems, make appropriate decisions, and employ technology in their daily lives. They will need to apply their education for success at work and in further education (Secretary's Commission on Achieving Necessary Skills [SCANS], 1991). All students, then, need TE throughout their elementary years as a foundation for developing technological literacy.

THE CONTENT AND PURPOSES OF ESTE

Definitions of technology, TE, and ESTE are helpful to consider the potential benefits of ESTE. For example, is activity-based applied science or research from *Science, Technology, and Society* endeavors appropriate to consider as TE? Is historical industrial arts research foundational, comparable, or even relevant to TE?

In *Technology for All Americans: Rationale and Structure for the Study of Technology* (TAAP, 1996) *technology* is defined as "human innovation in action" (p. 16). Wright and Lauda (1993) viewed technology as "a body of knowledge and actions, used by people, to apply resources in designing, producing, and using products, structures and systems to extend the human potential for controlling and modifying the natural and human-made (modified) environments" (p. 3). Whereas Savage and Sterry (1990) defined technology as "a body of knowledge and the systematic application of resources to produce outcomes in response to human needs and wants" (p. 7).

A synthesis of definitions of technology indicates that it consists of the knowledge, processes, and ingenuity that have enabled humans to conceive, design, and create tools and products as well as the systems that support them. Artifacts are made because people have needs or wants. They are made from a variety of materials, both natural and synthetic, dependent on their uses. They comprise the "built environment" in contrast to the "natural environment." Children need to understand this built environment, the means by which it is created, and the many consequences and by-products associated with its development and use.

Technology education has been defined as "an educational program that assists people in developing an understanding and competence in designing, producing, and using technology products and systems, and in assessing the appropriateness of technological actions" (Wright & Lauda, 1993, p. 4), or as "the study of technology and its effect on individuals, society, and civilization" (Savage & Sterry, 1990, p. 20). *Technological literacy*, the goal of TE, has been defined as "the ability to use, manage, and understand technology" (TAAP, 1996, p. 6).

There is considerable debate as to whether TE and industrial arts are, in fact, separate fields. *Industrial arts*, as conceived by Bonser and Mossman in 1923, was defined as "a study of the changes made by man in the forms of materials to increase their value, and of the problems of life related to these changes" (p. 5). While the definitions of TE vary, there are consistent patterns among them, and they are essentially the same in spirit as the conception of industrial arts offered by Bonser and Mossman. Conceptually, TE may be viewed as a descendent of industrial arts, although TE is broader in scope. In this paper, we assume that industrial arts, as defined above *and not necessarily as practiced in most schools*, was a

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precursor of TE.

TE in elementary schools may have a number of starting points including science, art, or a technological problem. Through TE, knowledge of other subjects is gained and applied in a variety of contexts. TE may therefore be viewed as an integrator of the curriculum. Some view TE as applied science; one learns the science through investigation (e.g., principles of structures) and then applies the resultant findings to a practical problem (e.g., bridges).

TE may also imply a process through which children learn. In this process they design and make a product, test it against identified criteria, and evaluate the outcome. During the process, children engage in imaginative, creative, critical thinking and they learn about the processes by which they achieve their goals (procedural knowledge).

PURPOSE YIELDS A DEFINITION

ESTE is much more than just a "watered-down" version of a secondary-level TE program. Indeed, the purpose of ESTE is different as well. ESTE may be viewed from at least two different perspectives: as *content* or as a *constructive methodology* (some would argue for the inclusion of *context* also). Each approach contributes to the development of children, but the underlying philosophies are quite different. Philosophical considerations are important because they determine not only the nature of the ESTE instruction, but also the palatability of a new educational program to teachers and administrators (Wright, 1997).

Gerbracht and Babcock (1959) stated that industrial arts in the elementary school "is not secondary-school industrial arts reduced in difficulty....Rather, industrial arts at the elementary (K-6) level is a means to an end" (p. 1). They suggested that elementary-school industrial arts should include "activities which involve constructive endeavor with material things" (p. 1). In a somewhat more controversial statement, they asserted

> industrial arts is not another "subject" to be squeezed into an already bulging curriculum. There is no standard content, as such, which must be covered. Industrial arts justifies its existence on the basis of the help it gives the school. It helps the school to do better the things the school is already trying to do. (p. 1)

Thus, they believed that the purpose of industrial arts at the elementary-school level was to assist the school in teaching other subjects better.

Scobey (1968) provided a definition for elementary school industrial arts in her foundational text, *Teaching Children About Technology*: "industrial arts in the elementary school is an authentic, inclusive study of industry and technology" (p. 7). In contrast to Gerbracht and Babcock (1959), she believed that industrial arts definitely had *content* to be learned and experienced in an authentic context; it was not just a *method* of teaching other school subjects.

In the content approach typified by Scobey (1968), technology is viewed as a unique body of knowledge (including a process for creating, designing, or modifying one's environment) and thus ESTE would have dedicated classroom time during the day or week, and like the content areas of science and social studies, would be added as a subject on the report card.

In the content approach to ESTE, technology is the primary focus. However, from the constructive methodology standpoint, ESTE is a method for teaching other school subjects as advocated by Gerbracht and Babcock (1959). This approach implies two beliefs: (a) children are more motivated via instruction through ESTE and will learn the other school subjects better and (b) technological content (knowledge and processes) will naturally be learned while students are engaged in constructional experiences, but are not of primary importance. Indeed, pilot projects have suggested that student interest in learning about technology cannot be stifled, even when the focus is initially on other subjects (Wright & Foster, 1996).

Because of teachers' heavy schedules, adding a new content area to elementary-school classrooms is not likely to succeed in the immediate future. Therefore, there is considerable agreement among TE professionals (Foster & Wright, 1996) that ESTE should also serve as a constructive methodology to teach other school subjects.

Ideally, a complete study of technology would use the content approach to ESTE. But the constructive-methodology approach is probably the most plausible method of introducing ESTE into classrooms—at least as a first step.

The current push for content integration is evident throughout educational literature in general. At the elementary-school level, this is happening largely through a thematic approach. Integration can and should involve all subjects, including technology. ESTE has the unique ability to help integrate and provide relevance to the elementary-school curriculum.

Because certain content, skills, and processes that are important and technological in nature do not fall within the boundaries of

ESTE as described above, I have built on the work reported in the preceding paragraphs to produce the following definition of ESTE: An educational program in which children engage in design and problem-solving, and/or constructional/manipulative activities to help them learn about themselves and the technological world around them, while critically assessing the appropriateness and consequences of technological actions.

Thus, programming a robot would be included within this definition as would learning to manipulate the technological world. Similarly, designing a device (which may not actually be built) as a solution to a problem would also be included. Learning about impacts and consequences of technological actions is critically important in the early years of children's education.

INSTRUCTION OF ESTE

What are the minimum components for a lesson or an activity to be considered TE? Must it be designed by a technology educator? Must it involve wood, metal, drafting, electricity, or printing? Does it have to end with a "take-home" project?

No, but it should be constructional, manipulative in nature, and authentic. It should engage students in *designing and making*, in creatively solving challenges that extend or enhance human capability while critically assessing the consequences of technological endeavors.

Are technology educators the only ones concerned about or qualified to implement and assess this kind of learning? Does the goal have to be "teaching TE content" specifically to count as a technological activity? That depends upon how TE content is defined.

I have already pointed out that technological literacy might be addressed in part by many different people, in various aspects of children's lives, not just in school, and definitely not just by technology educators. A great deal of technology instruction undoubtedly occurs on a daily basis in many components of the school curriculum. Out-of-school experiences may also contribute to technological literacy. A few examples of the diverse ways children might learn about and have experiences with technology are 4-H activities, scouting programs, playing at home with construction kits, tinkering in the garage, basement or kitchen, or through "Inventors Clubs" at elementary schools, organized by teachers who have never heard of TE.

The Hidden Technology Education Curriculum

Undoubtedly, there is a great deal of research, curriculum development, and innovative practice occurring regularly that TE professionals are unaware of because it is outside their paradigm of TE as the following are:

1. Especially worth noting because of the striking similarity to TE is a program Warnock and Hudiburg (1984) described as designed to assist third-grade students in raising funds for a project to construct, launch, and fly their own rockets. The perceived benefits include heightened confidence and self-perception among participants, hands-on experience in a highly technical area, and increased community support and involvement.

2. Hearing-impaired children (ages 6 and 7) were involved in a special practicum to develop critical thinking skills, including goal setting, deciding on necessary materials, designing and following a plan to reach the goal, and producing the product. Strategies included making flow charts, conducting hands-on activities, and having students view videotapes of themselves at work. The pretest-posttest results indicated that all children increased their critical thinking skills (Lins, 1993).

3. Kyker and Curchy (1995) provided a curriculum guide with step-by-step plans for 25 creative curriculum-based video projects. Equipment and techniques for video projects were described. The focus was on hands-on projects in the areas of social development, social studies, language arts, science, mathematics, and the like; however, the casual observer could probably not distinguish it from a communications technology activity.

4. *Suited for Spacewalking* (Vogt, 1994) is a curriculum guide for elementary teachers in physical and life sciences. Activities and related student projects make use of inexpensive and easy-to-find materials and tools.

5. Jobin (1991) described a curriculum project focused on rail transportation and its effect on the community. Although this geography project did not involve actually designing or making a model railroad, the author suggested hands-on activities in order to further explore the topic.

6. A curriculum project described by Sewall (1991) integrated science, environmental education, art, and social studies. Students researched an endangered species and constructed a totem pole depicting the species using recyclable materials.

These projects are consistent with the definition of ESTE used here, including using tools and materials in a constructive activity. They are illustrative of the type of research and curriculum development, conducted by practitioners outside the TE profession, that is clearly related to technological endeavors. Although hands-on science is not necessarily TE, there are many types of curriculum projects and research conducted by other educators that also meet the ESTE criteria. This underlines the importance of establishing parameters for ESTE in curriculum and research.

RESEARCH ON ELEMENTARY SCHOOL INDUSTRIAL ARTS AND ESTE

Downs' (1974) summary of elementary-school industrial arts research categorized the studies by doctoral, master's, and nondegree research. Zuga (1997) built on the database established by Downs (1974) and extended it through 1993 (see Table 1). Their work indicates that most doctoral studies related to ESTE occurred during the 1960s and 1970s.

Table 1

Doctoral Dissertations Identified by Downs or Zuga as Focusing on Elementary School Industrial Arts/ESTE by Decade

Decade	Number of Dissertations
1930-39	3
1940-49	3
1950-59	15
1960-69	29
1970-79	19
1980-89	5
1990-93	2

Zuga (1997) classified the studies in two broad categories of curriculum and student achievement. She reported that many curriculum studies were status studies which provided historical data, or benchmarks of the profession. The curriculum research has limited value to current researchers and curriculum developers because they were limited by specific points of time in describing public school practice and teacher education programs.

Curriculum Studies

Early studies documented the importance of pre-service and in-service education for successful implementation of ESTE. The successful implementation of ESTE has historically been based primarily on two factors: (a) its role in supporting the mission of the school and (b) the individual teacher's previous education and experience with TE, augmented by administrative support. The latter is the strongest argument for increasing efforts with in-servicing classroom teachers and principals.

Also in this category were studies about teacher education practices which show an interesting pattern. Duncan (1950) found that there was a relationship between the likelihood of a teacher using constructional activities and the amount of related education they had acquired. Scobey (1952) found that teachers had only a vague conception of industrial arts and needed more training with it. Low (1963) indicated that elementary-school teachers recommended that at least one industrial arts course be required. And Bruce (1964) found that 143 of 165 university teacher education departments offered elementary-school industrial arts courses. That number today is likely between one half and one dozen.

Zuga (1997) observed the important role played by ESTE leaders over the years in influencing adoption of the technological systems model. For example, Hoots (1968), as well as Scobey (1968), recommended studying communication, construction, manufacturing, transportation, power, and service in elementary school programs. At the teacher-education level, Gilbert (1955) developed a curriculum for teacher preparation that focused on manufacturing, construction, power, transportation, communication, and management. Similar curricular advances were made in the late 1980s with the Mission 21 project at Virginia Polytechnic Institute and State University (Barnes, Wiatt, & Bowen, 1990; Brusic, Dugger, & Dunlap, 1990; Brusic, Dunlap, Dugger, & LaPorte, 1988). Clearly, ESTE researchers were leaders in advocating the change from materials-based programs to a systems orientation. In spite of these influences and of those mentioned in the section titled "Purpose Yields a Definition," TE is not yet viewed as a core subject in elementary schools.

Student Achievement

The results of the research that focused on student achievement are summarized as follows: (a) Children's interest and motivation in other subject areas may be increased when TE is combined with or used as a method for teaching other school subjects and (b) students may become more independent learners through the inclusion of TE. However, there is no conclusive evidence to suggest that students learn the information better, or retain it longer, as a result of studying technology, with the possible exception of improvements in reading comprehension.

While the relationship among science, mathematics, and technology seems obvious to practitioners in the field, the evidence from these studies does not indicate that there is a significant gain in either science or mathematics achievement as a result of TE. However, preliminary research indicates that career education, language use, and reading comprehension may be significantly improved through TE. But substantial research to support irrefutable conclusions at this time is lacking.

More recent research studies that utilized qualitative or ethnographic methods are beginning to provide explanations about children's interests, the ways in which children interact with technology, and the benefits of TE to children.

Recent Research and Development

A team of researchers from the University of Missouri (MU) delivered in-service instruction to elementary-school faculty and administrators in five school districts in rural central Missouri and technology-related instruction to approximately 300 second- and fourth-grade students (Wright & Foster, in press). A summary of the results of their research follows, which is organized around four salient questions they sought to answer.

1. *Is there a relationship between educational achievement and students' attitudes toward technology?* The students' educational achievement and attitudes toward technology were studied for more than 100 fourth graders in four of these schools in central Missouri. No significant correlation (< - .01) was found between achievement in school (based on statewide, standardized tests in reading, language arts, social studies, science, and mathematics) and students' attitudes toward technology (using percentile scores from the Students Attitudes Toward Technology [SATT] instrument [Dunlap, 1990] developed at Virginia Polytechnic Institute and State University). This research would tentatively suggest that fourth-graders' attitudes toward technology cannot be predicted from their academic achievement.

2. *Can ESTE in-service training of elementary teachers be offered as effectively by a person without an extensive background in technology education?* The MU researchers also looked at the concerns of elementary teachers about implementing ESTE. I wondered whether in-service would be more effective when conducted by a person "from their ranks" (i.e., female and an elementary teacher) or from an individual with recognized expertise in the field. In order to examine this, elementary faculty at two schools received two in-service sessions from a male college professor with expertise in TE while faculty at the other two schools received two in-service sessions from a female kindergarten teacher with minimal ESTE background. These in-service instructors followed the same script in presenting the sessions.

The Stages of Concern (SoC) instrument (Hall, George, & Rutherford, 1986) was used to measure the elementary teachers' concerns. No significant difference was found in concerns about implementing ESTE between teachers attending in-service sessions presented by the two instructors. On average, teachers in all groups had increased SoC scores after the second in-service session, which indicates less concern about implementing the innovation (Hall, George, & Rutherford, 1986).

The results suggest that successful ESTE in-service sessions need not be presented by persons fitting the TE college-professor stereotype (highly experienced and male). They suggest that with minimal coaching and prepared materials an elementary teacher can be designated as an in-service provider for schools in his or her district. Further, in-service can be effective in reducing teachers' concerns about implementing ESTE.

3. *Do elementary students' interest and engagement in learning change when involved in technology education?* Two researchers conducted unobtrusive observations during a week-long technology unit taught by MU graduate students at a suburban elementary school in both a second- and fourth-grade class, then re-visited the classrooms during a subsequent week to observe the children in their normal environment (i.e., regular teacher, content, and schedule). Each faculty member watched two students closely while observing the class sessions.

The data suggest that most students do in fact respond positively to technology content and corresponding activities. Technology studies appear to meet different learning styles and address multiple intelligences better than conventional "seat work." TE activities appear to reach a wider range of children, perhaps as many as 75 to 80%, while many of the regular classroom lessons and activities appeared to captivate only about 20 to 25% of the children. It may be possible that the novelty of the subject matter or a new teacher was a factor in the students' behavior. It is also possible, even probable, that many students typically not motivated by conventional classroom strategies may be reached through relevant hands-on activities.

For example, one of the second-grade students who was previously identified by the teacher as "slow" exhibited a great deal of enthusiasm and leadership when provided the opportunity to work with tools and materials in a production setting. Conversely, a girl that was typically at the top of the class in academic achievement appeared to have no advantage over the boy labeled as "slow." Both quickly learned the names of the tools and the processes presented by the teacher, and both worked cooperatively in the ensuing activity, completing their tasks competently. It would appear from this particular episode that both students were equally capable. The "slow" student exhibited an uncharacteristically high degree of self-esteem and confidence during the technology lesson (evidenced by eagerly volunteering the answer to most questions) and activity (by attempting to assist other students and taking pride in his work). As these examples would illustrate, the range of children engaged and on-task through technology studies covered the spectrum from low to high academic ability.

Triangulation of observational data is imperative, we have learned. Interviewing children and teachers independently, for example, will reveal much richer understanding when used to supplement classroom observations. We also learned that educators are preoccupied with trying to get children to realize a conceptual understanding of technology when, in fact, children view things quite differently. The picture of technology in a student's mind may be significantly different from the picture in the instructor's mind. Constructivist learning theory would support our observations. Finally, our observations reveal that a great deal of technology is being done under other banners (science, social studies, and art, specifically) by the regular teacher.

4. *What are the benefits of TE to children?* Claims about the value of ESTE in general or of specific programs and activities are abundant in the literature. Foster (1997) conducted a qualitative study in order to identify some of the benefits of ESTE to children. The benefits Foster observed included (a) development of vocabulary, language use, and creative communication; (b) improved technological knowledge and capabilities; (c) practice with perceptual and motor skills, and skills such as graphic representation, visualization, design, and tool use; and (d) improved social and life skills such as engagement, responsibility, personal growth, and the ability to work with others. Foster concluded that TE professionals could help teachers to include design and constructional activities in their curriculum, thus helping to provide the benefits of ESTE to children.

WHAT MORE WE NEED TO KNOW AND WHAT WE MAY CONCLUDE

The need for additional research is obvious. Further, the base of existing research that we consider TE should be expanded. There is a considerable amount of TE research, curriculum development, and activity occurring in classrooms that is typically ignored by the TE profession because it is not conducted or developed by "technology educators" (e.g., Caney's third-grade rocket activity). Also, the research base should include a mix of experimental and qualitative studies. Qualitative studies could be useful to further explain how children benefit from or are affected by ESTE. When observations are conducted by technology educators with preconceived notions of technology, its value, and its structure, the use of triangulation is critically important.

Keeping in mind that the value of ESTE is largely a matter of unsubstantiated opinions, research should include longitudinal studies to more precisely identify the benefits students derive from TE and to explore what long-term participation in TE does for children. Further, because the ESTE implementation process is not yet well understood, we need to identify what can be done to facilitate the implementation of ESTE, assuming that research validates the value of TE. Finally, the content base for TE has largely been determined by people who are primarily interested in the upper grades and with a bias emanating from tradition. What is important for *all* boys and girls, K to 12, to know, be able to do, and value about technology has yet to be determined. Why, for example, is processing material (e.g., sawing) imperative for all children to understand and do?

This being said, I close with four observations that offer considerable challenge:

1. The TE profession does not have a clear understanding about its unique contribution to children, about what it does better than anyone else in the school. There are many claims of the benefits of ESTE to children, but no conclusive evidence to support the claims.

2. ESTE does appear to significantly enhance career education efforts and increase students' interest in other subject areas when used as a teaching method. However, based on the few research studies available, it does not appear to significantly increase student performance in other subject areas. Perhaps measures other than standardized tests should be used. Indeed, standardized tests may not be designed to assess what children are actually learning or are able to do as a result of technological studies.

3. There is little empirical research validating the need for or value of ESTE in the United States at this time. There are no longitudinal data available, nor are they being collected. A major research initiative is required to validate assertions that all children need or benefit from technology studies.

4. The successful implementation of ESTE must be based on the demonstrated need for technological literacy (content) for all, not just on its ability to teach other subjects better (method). The research base suggests that successful implementation will require three components: pre-service education, in-service education, and administrative support.

References

American Association for the Advancement of Science. (1989). *Science for all Americans: A Project 2061 report on literacy goals in science, mathematics, and technology*. Washington, DC: Author.

Anning, A. J. E. (1994, April). *Technological capability in the primary school classroom*. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Barnes, J., Wiatt, C., & Bowen, M. (1990). The NASA/elementary technology education project. *The Technology Teacher, 49*(4), 13–17.

Bonser, F. G., & Mossman, L. C. (1923). *Industrial arts for elementary schools*. New York: Macmillan.

Bruce, P. L. (1964). Status, content, and appraisal of industrial arts courses for elementary teacher education in public higher educational institutions. *Dissertation Abstracts International, 25*(10), 5760. (University Microfilms No. 6501038)

Brusic, S., Dugger, W. E., & Dunlap, D. D. (1990). *An overview of Mission 21*. Blacksburg, VA: Virginia Polytechnic Institute and State University. (ERIC Document Reproduction Service No. ED 334 407)

Brusic, S., Dunlap, D., Dugger, W. E., & LaPorte, J. E. (1988). Launching technology education into elementary classrooms. *The Technology Teacher, 48*(3), 23–25.

Downs, W. A. (1974). Research. In R. G. Thrower & R. D. Weber (Eds.), *Industrial arts for the elementary school: 23rd yearbook of the American Council on Industrial Arts Education* (pp. 237–308). Bloomington, IL: McKnight.

Duncan, G. S. (1950). Practical arts activities in elementary teacher education. *Dissertation Abstracts International, 10*(03), 54. (University Microfilms No. 0001779)

Dunlap, D. D. (1990). *Comparing attitudes toward technology of third and fourth grade students in Virginia relative to their exposure to technology*. Unpublished doctoral dissertation, Virginia Polytechnic Institute and State University, Blacksburg.

Dyrenfurth, M. J., & Kozak, M. R. (Eds.). (1991). *Technological literacy: 40th yearbook of the Council on Technology Teacher Education*. Peoria, IL: Glencoe.

Foster, P. N. (1997). *Benefits of elementary-school technology education to children*. Unpublished doctoral dissertation, University of Missouri, Columbia.

Foster, P. N., & Wright, M. D. (1996). Selected leaders' opinions of approaches to technology education. *Journal of Technology Education, 7*(2), 12–26.

Gerbracht, C., & Babcock, R. (1959). *Industrial arts for grades K–6*. Milwaukee, WI: Bruce.

Gilbert, H. G. (1955). An industrial arts teacher education program for elementary schools. *Dissertation Abstracts International, 16*(04), 708. (University Microfilms No. 0016073)

Hall, G. E., George, A. A., & Rutherford, W. L. (1986). *Measuring stages of concern about the innovation: A manual for the use of the SoC questionnaire*. Austin, TX: Southwest Educational and Development Laboratory.

Jobin, R. A. (1991). Trains, tracks, and nodal regions. *Journal of Geography, 90*(4), 160–163.

Johnson, J. R. (1989). *Technology: Report of the Project 2061 phase I technology panel*. Washington, DC: American Association for the Advancement of Science.

Hoots, W. R. (1968). *The development of a course of study for industrial arts education at the elementary school level*. Washington, DC: Office of Education. (ERIC Document Reproduction Service No. ED 024 022)

Kyker, K., & Curchy, C. (1995). *Video projects for elementary and middle schools*. Englewood, CO: Libraries Unlimited.

Lins, J. B. (1993). *Developing critical thinking skills in young hearing-impaired students, using realia, practice sessions, and parent involvement*. (ERIC Document Reproduction Service

No. ED 367 080)

Low, F. G. (1963). A study of industrial arts skills and teaching techniques as appraised by elementary teachers compared to those taught by California colleges. *Dissertation Abstracts International, 25*(01), 192A. (University Microfilms No. 6404195)

National Council for the Social Studies. (1994). *Expectations of excellence: Curriculum standards for social studies*. Washington DC: Author.

Paulos, J. A. (1990). *Innumeracy*. New York: Random House.

Raizen, S. A., Sellwood, P., Todd, R. D., & Vickers, M. (1995). *Technology education in the classroom*. San Francisco: Jossey-Bass.

Savage, E., & Sterry, L. (1990). *A conceptual framework for technology education*. Reston, VA: International Technology Education Association.

Scobey, M. M. (1952). *Industrial arts for elementary teachers*. Unpublished doctoral dissertation, Stanford University, Stanford, CA.

Scobey, M. M. (1968). *Teaching children about technology*. Bloomington, IL: McKnight.

Secretary's Commission on Achieving Necessary Skills. (1991). *What work requires of schools: A SCANS report for America 2000*. Washington, DC: Department of Labor.

Sewall, S. B. (1991). The totem pole recycled. *Science and Children*, *29*(2), 24–25.

Technology Education Advisory Council. (1988). *Technology: A national imperative*. Reston, VA: International Technology Education Association.

Technology for All Americans Project. (1996). *Technology for all Americans: A rationale and structure for the study of technology*. Reston, VA: International Technology Education Association.

Vogt, G. L. (1994). *Suited for spacewalking: Teacher's guide with activities for physical and life sciences*. (ERIC Document Reproduction Service No. ED 381 392)

Warnock, J., & Hudiburg, G. E. (1984). Caney's third grade rocket program. *Small School Forum, 6*(1), 5–7.

Wright, M. D. (1996). *Research in elementary school technology education.* Paper presented at the 83rd Mississippi Valley Industrial Teacher Education Conference, St. Louis, MO.

Wright, M. D. (1997). Connections: Technology education and the elementary curriculum. In J. J. Kirkwood & P. N. Foster (Eds.), *Elementary school technology education: 46th yearbook of the Council on Technology Teacher Education* (pp. 27–33). Peoria, IL: Glencoe.

Wright, M. D., & Foster, P. N. (1996). Constructive activity for teaching elementary-school math and communications. *The Technology Teacher, 56*(2), 21–25.

Wright, M. D., & Foster, P. N. (in press). The development of a model for the implementation of elementary-school technology education.

Wright, R. T., & Lauda, D. (1993). Technology education—A position statement. *The Technology Teacher, 52(*4), 3–5.

Zuga, K. F. (1994). *Implementing technology education: A review and synthesis of the research literature*. Columbus, OH: Center on Education and Training. (ERIC Clearinghouse on Adult, Career, and Vocational Education Information Series No. 356)

Zuga, K. F. (1997). Research in elementary school technology education. In J. J. Kirkwood & P. N. Foster (Eds.), *Elementary school technology education: 46th yearbook of the Council on Technology Teacher Education* (pp. 305–335). Peoria, IL: Glencoe.