DOCUMENT RESUME

ED 354 340 CE 063 049

AUTHOR Lewis, Theodore
TITLE The Nature of Technology and the Subject Matter of Technology Education--A Survey of Industrial Teacher Educators.
PUB DATE 4 Dec 92
NOTE 36p.; Paper presented at the Annual Meeting of the American Vocational Association (St. Louis, MO, December 4, 1992).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Course Content; *Curriculum; Curriculum Development; *Educational Change; Educational Research; Higher Education; Literature Reviews; Postsecondary Education; *Program Content; Program Development; Secondary Education; *Teacher Education; Teacher Educators; *Technology; *Technology Education
IDENTIFIERS International Technology Education Association

ABSTRACT

A sample of industrial teacher educators (n=392) responded to a questionnaire on technology teacher education reform, two segments of which focused on the nature of technology and on the subject matter of technology education. A literature review had shown that a philosophical discussion continued to characterize the field of technology education; the field of philosophy of technology and the science/technology/society movement were also preoccupied with the struggle to set forth a coherent epistemology of technology. Responses to the survey were via Likert-type scales. Data were analyzed using factor analysis and stepwise regression analysis. Factor analysis resolved items pertaining to the nature of technology into six factors, the predominating one being applied science. The subject matter of technology was resolved into seven factors, with innovative curricula predominating. Regression analyses revealed membership in the International Technology Education Association to be the most consistently significant independent variable predicting factors relating both to the nature of technology and the subject matter of technology education. (Appendixes include 30 references and 8 data tables.) (Author/YLB)

The Nature of Technology and the Subject Matter of Technology Education--A survey of Industrial Teacher Educators

by

Theodore Lewis
Assistant Professor

A Paper delivered at the American Vocational Association Conference, St. Louis, Missouri
Friday, December 4, 1992

Department of Vocational and Technical Education
University of Minnesota
1954 Buford Ave
St.Paul, MN 55108
Tel: 612-624-4707
Fax:612-624-4720

Acknowledgements

The author thanks Rick Boser, and Professors Rodney Custer, Robert Putnam, Jerome Moss, and David Bjorkquist for serving as an expert panel in critically reviewing early drafts of the questionnaire. Professor Moss is thanked further for a critical reading of an earlier draft of this article. John Hansen is thanked for serving as Research Assistant for the project.

Abstract

A sample of Industrial Teacher Educators (N = 392) responded to a questionnaire on technology teacher education reform, two segments of which focused respectively on the nature of technology, and the subject matter of technology education. Responses were via Likert-type scales. The data were analyzed via Factor Analysis and Stepwise regression analysis. Factor analysis resolved items pertaining to the nature of technology into six factors, the predominating one being APPLIED SCIENCE. The subject matter of technology was resolved into seven factors, with INNOVATIVE curricula predominating. Regression analyses revealed ITEA membership to be the most consistently significant independent variable predicting factors relating both to the nature of technology and the subject matter of technology education.

The Nature of Technology and the Subject Matter
of Technology Education--A Survey
of Industrial Teacher Educators

One of the more challenging aspects of the transition from industrial arts to technology has been to determine the epistemological limits of technology education, that is, to decide where does the study of technology begin and end. Defined too broadly, technology presents an onerous curricular problem. Arguably, technology is evident in all phases of human existence. How then do we go about making choices about how to represent it in the technology education curriculum?

Recent Literature

The recent literature of the field provides evidence that epistemological questions continue to engage the scholars. Kuskie (1991) suggests that the transition to technology education should begin with the development of a "technology-based philosophy" (p. 32). Those seeking to make curricular change, he argues, should seek out information which would help them to develop such a philosophy. Dugger (1988) has argued that technology should be taken to be a "formal, or academic, discipline" (p. 3). He suggests that inquiry into the discipline of technology ought to begin with consideration of what technology is. Locatis (1988) raises important issues regarding the nature of technology. He points out the need to take into account the relationship between science and technology, the question of values and technology, and the existence of social as well as physical technologies. Pullias (1992) points out that the education reform movement of the mid-1980s has served as a catalyst in the discussion about just what technology (and hence technology education) really is. He goes on to take issue with the notion that the technology education curriculum should be compartmentalized into "manageable chunks" such as energy, communication or transportation, arguing that "(I)f technology education is to teach about technology, it cannot be fragmented" (p. 3).

Indeed, as Pullias (1992) points out, the education reform movement now provides a new and compelling reason for considering the question of the nature of technology and the subject matter of technology education. For example, a key proposal of the Holmes Group (1986) was that pre-service teachers should get from their coursework "a sense of the intellectual structure and boundaries of their discipline" (p. 16). Subject matter knowledge was set forth in the Holmes Group Report as one of three key elements of competent teaching (p. 62). The Holmes Group proposal to extend the teaching degree to a fifth year was premised on the idea that more time would be needed during the first four years of pre-service teacher education to gain subject matter mastery.

As is evident in Johnson, Erekson, Dugger, & Blankenbaker (1990), and in Lewis (1991), technology teacher education will surely be affected fundamentally by the reform movement. And thus, while issues such as the fifth year may be dismissed as being unrealistic, the question of the nature of the subject matter of the field would require continued attention. Agreement as to what technology is and what subject matter should be the content of technology education are prerequisites to the reform of technology teacher education.

<u>History</u>

Technology education has a rich history of scholarship upon which to draw as the field continues to ponder the question of the nature and conceptual structure of its subject matter. Warner (1965) provided the initial insight to the field when, along with his doctoral students, he suggested that there should be a "new industrial arts" that would be based upon "a socio-economic analysis of the technology" (p. 41). Subject matter would now include *power*, *transportation*, *construction*, *communication*, and *management*. Warner's ideas began to take hold in the 1960s through the instrumentality of several major innovative curriculum projects, along with seminal writings on epistemological issues relating to technology (see for example Towers, Lux, & Ray, 1966; and DeVore, 1967 and 1969).

For their Industrial Arts Curriculum Project (IACP), Towers et al (1966) conceived of technology as the sum of all human practices. Such a broad view of technology created for the project leaders what they referred to as a "conceptual problem," namely, how to conceive of an elegant framework that would totally encapsulate it. The project leaders set forth only an outline of such a framework, and then concentrated efforts at articulating one aspect of technology, namely, industrial technologies. Industrial technologies were said to comprise of two major sub-sets, namely manufacturing and construction technologies.

DeVore (1967) proposed a taxonomy of technology comprised of three main sub-sets, namely *production*, *communication*, and *transportation*. These technologies were set forth as "cultural universals" to be found in all cultures irrespective of their stage of development.

Adding to the discourse that sprung from the innovative movement of the 1960s, Olson (1972) provided a broadly conceived definition of technology, as follows:

> Technology is the material culture. It is the total of what man knows about and does with materials. It has a history as old as pre-man and a future as great as man's imagination. Technology is man creating his own environment on earth, in air, in space ... Technology is man gaining advantage over nature ... Technology is the goods and services and the production thereof as today's industries. (p. 34)

While Olson was able to set forth broad manifestations of technology, he omitted any reference to it as a discipline with a unique conceptual structure, and a unique methodology.

The decade of the 1980s saw an attempt at curricular consolidation, testimony to the fact that issues from the innovative period of the 1960s and 1970s remained to be dealt with. Toward the goal of curricular consolidation--a new synthesis--the Jackson's Mill Movement (Hales & Snyder, 1982a & b) recognized technology as the subject matter of the field. Technology was conceived as the knowledge deriving from human endeavors. There was consensus that technology could better be studied within the context of industry, through the universal technical systems of manufacturing, construction, communication, and transportation.

Reviving the work of the Jackson's Mill movement in the 1990s, Savage & Sterry (1990a & b) reiterated that technology is a discipline. However, the major conceptual boundaries of technology were now to be *bio-related*, *communication*, *transportation*, and *production*. The inclusion of bio-related technologies was a significant departure from earlier conceptions, highlighting the state of flux that still attends the discourse on what constitutes the subject-matter of the field.

Discourse in Other Fields

But technology educators are not alone in their struggle to set forth a coherent epistemology of technology. Outside of the field, scholars who make technology a focus have been similarly preoccupied.

Philosophy of Technology. Philosophers of technology point to difficulties that they attribute to the traditional Platonic bias against consideration of practical affairs as being worthy of philosophical speculation (see for example Rapp, 1989; Downey, Donovan & Elliot, 1989; Durbin, 1990; Skolimowski, 1972; and Jarvie, 1972). Rapp (1989) points out that unlike other spheres of philosophical inquiry, philosophy of technology lacks "a well elaborated state of the art" (p. ix). Other fields have had "long standing discussions; there is a well established, systematic conceptual framework of basic concepts, questions, theses, and arguments ... there is a clearly established level of scholarly discussion" (p. ix), whereas philosophy of technology lacks similarly elaborate theoretical underpinnings.

The concerns of philosophers of technology are exemplified in the following excerpt taken from Downey et al (1989) as they discuss the nature of engineering, and the problems that attend consideration of technological theory as knowledge:

> In the years following World War II, the philosophy of science had gained new legitimacy within the discipline (of science) as a mode of investigation that produces useful evidence about the nature and content of knowledge. But because technology was generally understood as referring either to artifacts or to the wholly practical, that is, nontheoretical and context-bound, activity involved in their production, philosophers tended to view it

> either as totally irrelevant to epistemology or, at best, as the product of applying science and, hence, merely a secondary source of evidence. (p. 198)

Science/Technology/Society. Issues raised by philosophers of technology are evident in the STS (Science-Technology-Society) movement. This movement seeks to make science more applied and more contextual. However there has been concern that STS understates technology, deeming it to be no more than applied science. The difficulties here are captured by Layton (1988), and Roy, 1989. Layton argues that STS curricular ventures tend to view technology as an after-thought. In discussing this problem he points to the historical tendency to view technology "as the routine, tedious, and menial application of the seminal products of pure science" (p. 369).

Reflection

Taking the philosophical discussion that continues to characterize the field of technology education together with the problems of the fields of philosophy of technology, and STS, what emerges is the need for advocates to at least agree on some minimums. Two crucial ones appear to be (a) that technology is a sphere of knowledge in its own right--that it is autonomous, and (b) that technology is therefore not applied science.

But it is not at all clear from the various strands of discourse on technology that there is this level of agreement. As is evident in Dugger (1988), Lewis (1991), and Lewis & Gagel (in press), philosophical hurdles abound in the quest for such agreement. How technology is viewed and defined is still in large measure a matter of one's scholastic orientation. An example of the difficulties here is the view of the

Project 2061 panel--a view from an important segment of the scientific community--that technology's role is "doing, making, and implementing things," while the role of science is "understanding." Is this a satisfactory conception of technology? Is there not more to technology than doing, making, and implementing? Does technology not include thinking? This is the problem that Layton (1988) addresses in the case of STS. Another example of the attendant difficulties is the proposition that bio-related technologies should be a major conceptual organizer of technology education.

The above discussion foreshadows results that are excerpted from a larger study referred to as the Reform of Technology Teacher Education Survey. The focus was on two central and related concerns within the field of technology teacher education, and in the field of technology education generally, namely, *the nature of technology*, and *the subject matter of technology education*. These have always been important issues in the field, once the transition from industrial arts to technology education had begun. They have become more crucial now, in that discipline structure and subject matter knowledge have been set forth as key aspects of teacher education reform.

Purpose

The overall purpose of the Reform of Technology Teacher Education Survey was to discern the extent of agreement among industrial teacher educators regarding the efficacy of specific programmatic reforms pertaining to the pre-service curriculum. A critical aspect of the study was whether a consensus position relating to subject matter could be discerned within the field. To be reported in this article, then, are findings that addressed two related questions: (a) what is the disposition of industrial teacher educators regarding the nature of technology? and (b) what does the field deem to be relevant constituents of the subject matter of technology education? The investigation further sought to discern the sources of any variability within the field regarding these two concerns.

Method

Sample and Procedures

Survey questionnaires were mailed to a systematic sample (see Babbie, 1973, p. 92) of 535 teacher educators listed in the 1990-1991 edition of the Industrial Teacher Education Directory. While all industrial teacher educators are not advocates of technology education, or teachers of technology-related coursework, it was assumed that they practice in a common scholastic culture in which they are full participants. They are members of the same community of scholars. Respondents who did not have a view on the issues dealt with in the questionnaire of course had the option of not responding. The survey was conducted over the period March to July, 1991. Two mailings and a post-card follow-up yielded a return of 392 respondents (a response rate of 73.3%). Comparison of the responses of early (first mailing) and late (second mailing) respondents on selected items revealed no observable differences.

Independent Variables

To assure that plausible sources of variability within the field were taken into account in the analysis, the following independent variables were built into the design of the study:

a. Whether the program of the respondent was located in a College of Education.

b. Whether the home institution of the respondent was a member of the Holmes Group.
c. Rank, i.e., Full Professor versus Associates, Assistants and Instructors taken together.
d. Teaching emphasis, i.e., Professional courses versus Technical or Laboratory type courses.
e. ITEA membership or Not.
f. NAITTE membership or Not.
g. Number of years as a university faculty member.
h. Highest degree granted by program, i.e., Bachelors and Masters taken together, versus Doctorate and Ed.S. taken together.

Variables (a) and (b) above were determined, respectively, from the Directory of Industrial Educators and from a published list of the institutional members of the Holmes Group set forth in the executive summary of Tomorrow's Schools (Holmes Group, undated). The remaining variables were self reported in the demographics section of the questionnaire.

Respondents

As indicated above, the survey attracted 392 respondents, each having multiple affiliations, a function of demographics. Therefore, the cell sizes to be set forth here are not mutually exclusive. Representation for each variable was as follows: 109 respondents were from Colleges of Education; 80 were from Holmes Group Institutions; 145 were full professors; 136 had a professional teaching emphasis, and a further 150 had a technical/laboratory teaching emphasis; 232 were ITEA members; 117 were NAITTE members; and 143 were from Doctorate and Ed.S. granting institutions.

Years of experience was treated as a continuous variable, and the statistics for the respondents were as follows: range = 0-45 years, mean = 17.74 years, and standard deviation 9.4 years.

Survey Instrument

The Reform of Technology Teacher Education Survey instrument consisted of six content sections, namely (1) the nature of technology, (2) the subject matter of technology education, (3) the liberal education component, (4) the professional component, (5) the clinical component, and (6) the nature of teaching and of acquiring teacher capability. A seventh section was devoted to demographics. The content of the survey was informed substantially by issues gleaned from the literature on (a) teacher education reform, (b) philosophy of technology, (c) the STS movement, and (d) technology teacher education. Drafts of the questionnaire were critically reviewed by an expert panel of Industrial Educators. Based upon this review process, the final form of the questionnaire came to reflect a blend of the reform concerns of mainstream teacher education as well as those specific to technology teacher education. This review process also helped in the critical task of identifying background variables that plausibly could be considered sources of variability on the question of reform of technology teacher education.

The current article is based on results from sections (1) and (2) above. Section (1) had as its theme *the nature of technology*. It included 16 questionnaire items that were statements determined from the literature to be points at issue in the discourse on the nature of technology. Instruction given to respondents was as follows:

> Following is a list of statements which reflect stances one may take regarding the nature of technology. Kindly react to each indicating the extent of your agreement or disagreement with the view that it reflects what technology is, or what it entails.

Options included:

"Technology is applied science,"
"Technology, like science, is confined by the laws of nature,"
"Technological problems differ from scientific problems," etc.

Respondents indicated their preferences on a five-point Likert-type scale inclusive of the following points:

1. Strongly Disagree (Statement conflicts radically with my view)
2. Disagree (Statement is inconsistent with my view)
3. Neutral (Statement does not provoke me either way)
4. Agree (Statement conveys my view)
5. Strongly Agree (Statement exemplifies my view)

Section (2) consisted of 28 questionnaire items that were topics or processes that find varying degrees of support in the literature as constituents of the *subject matter of technology education*. The items reflected both contemporary and traditional subject matter, and in the estimation of the expert panel were consistent with the range of content options available to the field. The respondents were asked the following:

> How relevant is the study of each of the following topics/processes to the development of an understanding of the nature and structure of technology, within the context of the technology teacher education curriculum?

Options included:

"History of Technology,"
"Manufacturing,"
"Woodworking,"
"Critical thinking/Problem solving," etc.

Respondents indicated the degree of relevancy of each via a four-point Likert-type scale with the following points:

1. Irrelevant (of no value)
2. Marginally relevant (of little value)

3. Relevant (of some value)
4. Critically relevant (of fundamental value)

Results

Following Kerlinger & Pedhazur (1973), a two-stage approach was taken in analyzing the data. First, factor analysis was employed to discern the factor structure of the data, and to derive factor-scores. Second, factor-scores thus derived were employed as dependent variables in subsequent stepwise regression analyses. In the stepwise procedure, each independent variable is entered into the regression equation in turn, according to the amount of unique variance it explains after the effects of other variables are taken into account. In the stepwise procedure an independent variable that singularly accounts for variability in an outcome may prove to be insignificant when other variables enter an equation.

Factor Analysis: The Nature of Technology

Principal components analyses with varimax rotations were conducted on the data using the FACTOR option of the Statistical Packet for the Social Sciences (SPSS). Analysis of the data for Section (1), *the nature of technology*, produced 6 factors with eigenvalues ≥ 1.0 and accounting for 65.8% of variance (Table 1). With one exception, all factor loadings were in excess of .50, indicative of a high degree of significance. Loadings reflect the degree of correlation between a questionnaire item and a factor. Of the 6 factors, 2 were judged to be uninterpretable (because their constituent items did not suggest a dominant theme) and not considered in further analysis. The remaining 4 were named as follows: APPLIED SCIENCE, METHOD/PROCESS, PRAXIS, and KNOW-HOW. Factors are named on the basis of the theme that predominates their constituent items. Table 2 shows the questionnaire items that corresponded to the six-factor solution shown in Table 1.

Table 1 about here

Table 2 about here

Factor Identification and Description

Factor 1. As shown in Table 1, the dominant factor was named Applied Science, since this was the theme held in common by the four questionnaire items (see Table 2) that constitute the factor. This factor accounted for 22% of variance. Respondents who scored high on this factor believed that technology was applied science, that it relied on the scientific mode of thought, and that like science, it was bounded by the laws of nature.

Factor 2. This factor was named Method/Process because it focussed on technological problems, inquiry, and solutions. It accounted for 13% of variance (Table 1). Those scoring high on this factor made a distinction between scientific methodology and the methodology of technology. What makes this factor emphatic is its negative correlation with item 14 which states that technological inquiry must conform to the scientific method. This factor differs conceptually from Factor 1 in that it concedes that technology requires a process of inquiry that's different from science.

Factor 3. This factor was named Praxis, since it derives from questionnaire items (Table 2) that characterize technology in terms of its tangible products (artifacts) and its hands-on approach (doing). It explained 9.4% of variance (Table 1).

Factor 4. This factor was named Know-how, a term which appeared to summarize the main theme of the two questionnaire items (Table 2) that constitute it, one positing technology as human efficient practices, and the other as capability or know-how. This factor accounted for 7.8% of variance (Table 1).

Stepwise Regression Analysis: The Nature of Technology

Table 3 shows a summary of the regression solution for factors related to *the nature of technology*. Reported are significant regression coefficients (Bs), with their attendant standard errors (shown in parentheses). Probabilities associated with the T-statistic, resulting from significance tests of the slope of the regression equation at the entrance of each variable are indicated. Also shown are multiple R, R-square (variance explained), and the constant or error term values for each equation.

Table 3 about here

The table shows that when the factor APPLIED SCIENCE was regressed upon by all of the independent variables in the analysis, only the variable Rank met the test of significance ($P \leq .01$). Full professors were less inclined than faculty of lower rank to agree that, essentially, technology was applied science.

When the factor METHOD/PROCESS was regressed upon, the only significant variable entering the regression equation was ITEA membership. As is evident from the comparison of means evident in Table 4, the mean scores associated with ITEA members were significantly higher than that for non-members on all three items that comprised this factor. ITEA members were significantly more likely to agree that

---

Table 4 about here

---

technological problems and solutions differed from scientific problems and solutions, and less likely to agree that technological inquiry must conform to the scientific method. This was a major finding of the study.

Two background variables, ITEA membership and Experience (a continuous variable), proved significant at $P \leq .01$ when the factor PRAXIS was regressed upon. Again, as is evident in Table 4, ITEA members indicated a greater degree of agreement than non-members with the items that were associated with this factor. Beyond ITEA affiliation, the greater the number of years of experience possessed by respondents, the more they were likely to agree with these propositions.

When the factor KNOW-HOW was regressed upon, ITEA membership again emerged, this time as the sole significant variable. Table 4 shows that the difference between members and non-members was particularly evident on the item suggesting that technology refers to all human efficient practices.

Factor Analysis: The Subject Matter of Technology Education

Analysis of the data relating to Section (2), *the subject matter of technology education*, produced 7 factors with eigenvalues ≥ 1.0, and accounting for 70.4% of variance (Table 5). All 7 factors were judged to be interpretable, and named as follows: INNOVATIVE, CONTEXT, BIO-RELATED, TRADITIONAL, HISTORY, SYSTEMS/PROCESSES, and CREATIVITY. Table 6 shows the questionnaire items associated with each of the even factors.

Table 5 about here

Table 6 about here

Factor Identification and Description

Factor 1. This factor was named Innovative because the topics or processes which predominate it bear titles that are associated with contemporary conceptions of the technology curriculum. They included construction, manufacturing, communications, transportation, power/energy, and structure/organization of industry. This was the dominant factor, explaining 26.8% of variance.

Factor 2. Factor 2 was named Context because the Topics/Processes that predominate it had to do with social, economic, political and moral issues attending technology, as well as the evaluation of technology. This was a major factor, accounting for 17.1% of variance explained.

Factor 3. This factor was named Traditional, for reasons that are self-explanatory. Persons scoring high on it were supportive of the inclusion of metalworking, woodworking, and plastics, as the subject matter of technology education. This factor explained 8.3% of variance.

Factor 4. This factor was named Bio-Related technology to capture the common theme in the two topics that constitute it. The topic with the higher loading was bio-related technology, a concept that is associated with Savage & Sterry (1990a & b). Technologies relating to food and health are consistent with a broader conception of technology, and is evident in the conceptual framework set forth by Towers et al (1966). This factor accounted for 5.5% of variance.

Factor 5. History was clearly the dominant theme of this factor. Persons scoring high on it supported the inclusion of biographies of famous inventors/innovators, history of technology, history of science, and the structure of technological knowledge (an outlier) as aspects of the content of technology education. This factor explained 4.9% of variance.

Factor 6. Factor 6 was named Systems/Processes to capture the essence of its constituent items which are systems theory, production, materials, and industrial process. This was an important, but not dominant factor. It explained 4.2% of variance.

Factor 7. This factor was named Creativity, in character with the constituent items which were creativity, design, and critical thinking/problem solving. It explained 3.7% of variance.

Stepwise Regression Analysis: The subject-matter of technology education

When the factors related to *the subject matter of technology education* were regressed upon, only three of the seven yielded equations in which the coefficients met the $P \leq .01$ requirement. Table 7 shows that they were CONTEXT, TRADITIONAL, and HISTORY. ITEA membership featured as a significant variable in all three cases.

Table 7 about here

There were three significant predictors of the dependent variable CONTEXT, namely ITEA membership, Location (within a College of Education), and Highest Degree granted, in that order. ITEA membership, affiliation with Doctorate and Ed.S. granting institutions, and location outside of colleges or departments of education, inclined respondents to a significantly higher degree of agreement with the view that the subject matter of technology should include social, political, moral, and economic aspects.

Table 8 about here

ITEA membership alone predicted the dependent variable TRADITIONAL. This time, members were less inclined than non-members to agree that traditional staples (woodworking, metalworking, plastics) were aspects of the subject matter of technology. But the difference between the two groups was only in degree--across the board there was little support for tradition as subject matter.

Again, ITEA membership alone predicted the dependent variable HISTORY. Members were more inclined than non-members to deem an appreciation of topics such as history of technology, history of science, or biographies of famous inventors to be relevant to an understanding of technology. (Table 8 isolates and compares the means of ITEA members and non-members on the factors CONTEXT, TRADITIONAL, and HISTORY.)

In reflecting upon the results of the stepwise regression analyses, a cautionary note becomes necessary, based upon the relatively small R^2 evident in Tables 3 and 7. Typically, R^2 ranged from 1% to 12%. These small values are not atypical in research premised on attitudes and perceptions, where a degree of specification and measurement error is to be expected. The variable ITEA, for example, while a valid descriptor of a sub-set of respondents, could be expected to reflect variation. All ITEA members do not think alike. The small R^2 values may mean then that much of what causes variation among the sample in this study remains unknown. However, because of the stringency employed in the analysis ($P \leq .01$), the variables that have emerged cannot lightly be dismissed. ITEA membership in particular consistently emerged significant with probability values that effectively ruled out chance.

Discussion

A central premise of this investigation was that agreement about subject matter ought to be a prerequisite of reform of technology teacher education. Therefore, respondents were asked to indicate their dispositions regarding two related concerns--*the nature of technology*, and *the subject matter of technology education*. How industrial educators reacted to the premises set forth in the survey instrument provides clues as to whether or not there is consensus regarding these concerns, and if not, on what points, and along what lines is there disagreement. Results relating to each of the concerns are now discussed in turn.

The Nature of Technology

The results of factor analysis indicate that technology was perceived by the respondents to be a multi-dimensional construct inclusive of a predominating applied science aspect, a significant method or process aspect, a praxis aspect that entails "doing" and the actual making of artifacts, and a know-how aspect. That the respondents accepted "praxis" and "know-how" as being fundamental to the nature of technology confirms the pragmatic ethic of the field, and is in keeping with the general ethos of programs of technology teacher education. More problematic are the findings relative to the other two factors.

That an applied science orientation was the predominating aspect of technology is disconcerting. Two explanations for this suggest themselves. The first is that the respondents euphemistically conceive of the term "applied science" as the way to express the peculiar character of technology. They do not in anyway intend to imply that technology is subordinate to science. If this explanation is correct, it would mean simply that the field needs to agree on more precise language. However, a second explanation is that the field does indeed share the view that technology is no more than applied science. This would mean that technology is not viewed as being an autonomous sphere of knowledge. The case for technology as a unique subject matter becomes difficult to make if the field takes this latter view of the nature of technology. Not that this is a settled philosophical issue. Earlier in the paper the views of philosophers of technology and advocates of STS were set forth in this regard, along with a sense of the contentions in their respective fields.

While there was general agreement among the sample on the question of the science basis of technology, there was disagreement on the related question of the nature of inquiry, that is, whether the problems, processes and solutions of technology are different to that of science. Examination of differences on the METHOD/ PROCESS factor made this evident, showing that ITEA membership was the best predictor of those respondents who were inclined toward the view that on the method/process question technology was distinct from science. But while ITEA members were prepared to allow that technology required its own methods and procedures, it must be borne in mind that they did not distinguish themselves significantly from the rest of respondents on the more fundamental question of its status, per se, relative to science.

The Subject Matter of Technology Education

The results of this aspect of the investigation showed that like technology itself, the subject matter of technology education is perceived by respondents to be multi-dimensional. What is heartening for the field is that the dominant aspect of this subject matter was deemed by the respondents to be innovative curricular areas (manufacturing, construction, transportation, energy, etc.). Also heartening was that there was no significant variability among the sample with respect to this factor, an indication of consensus.

The counterpart of innovative curricula, traditional curricula, emerged interestingly as a discernible facet of the subject matter of technology education. However, support was not strong overall, Though, as earlier indicated, there were sharp differences along lines having to do with ITEA affiliation, such differences could for practical purposes be ignored.

That the respondents in this study supported (though only modestly) the notion that an historical perspective (biographies, history of science, history of technology, etc.) is germane to the study and understanding of technology is encouraging. To keep the essence of technology in perspective requires an historical sense. Already, based on evidence presented earlier, the modern linkage of technology and science seems to have distorted the perspective of the field as to the essential nature of technology. An historical sense would provide a needed critical perspective, and the basis for challenges to orthodox views about technology's nature. Again it was encouraging that ITEA membership provided the only source of variability on this issue, in a positive direction.

Summary

The two related components of this investigation, the nature of technology, and the subject matter of technology education, were resolved into a total of 11 interpretable factors. It is remarkable that when these factors were treated as outcome variables and considered in regression equations, ITEA membership explained variability in 5 of the 11 cases. Because of the consistency of this variable, the main finding of this investigation is that on the question of the subject matter of the field, whether or not an industrial teacher educator is a member of the ITEA provides us with the best clue as to that person's curricular philosophy with respect to technology.

A second finding of this investigation is that, contrary to the philosophical roots of the technology education movement, the field appears to have comprehensively embraced the notion that technology is applied science. This position precludes support for technology as an autonomous sphere of knowledge. The dilemma here is that unless technology is seen to be independent of science, that is, to be of epistemological consequence on its own, then discussion about and the quest for derivation of its conceptual structure is rendered moot.

References

Babbie, E. R. (1973). Survey research methods. Belmont, California: Wadsworth Publishing Company Inc.

DeVore, P. W. (1967). Curricular considerations--Oswego. (ERIC Document Reproduction Service No. ED 016 069)

DeVore, P. W. (1969). Knowledge--Technology and curriculum. Addresses and Proceedings from the 31st Annual Conference of the American Industrial Arts Association (pp. 41-54).

Downey, G. L., Donovan, A., & Elliot, T. J. (1989). The invisible engineer: How engineering ceased to be a problem in science and technology studies. In L. Hargens, R. A Jones, & A. Pickering (Eds.), Volume 8, (pp. 189-216). Greenwich, Connecticut: JAI Press Inc.

Dugger, W. E. (1988). Technology--The discipline. The Technology Teacher, 48(1), 3-6.

Dugger, W. E., French, B. J., Peckham, S., & Starkweather, K. N. (1991). Sixth annual survey of the profession. The Technology Teacher, 50(4), 10-14.

Durbin, P. T. (1990). Conflict over philosophy of technology as an academic field. In P. T. Durbin (Ed.), Broad and Narrow Interpretations of Philosophy of Technology. Philosophy and Technology, Vol. 7, (pp. ix-xvii). Boston, MA: Kluwer Academic Publications.

Face, W. L. (1967). The American industry project. Addresses and Proceedings of the 29th Annual Conference of the American Industrial Arts Association (pp. 18-19).

Hales, J. A., & Snyder, J. F. (1982a). Jackson's Mill industrial arts curriculum theory: A base for curriculum derivation. Part I. Man Society Technology, 41(5), 6-10.

Hales, J. A., & Snyder, J. F. (1982b). Jacksons Mill industrial arts curriculum theory: A base for curriculum conceptualization. Part II. Man Society Technology, 41(6), 6-8.

Holmes Group. (1986). Tomorrow's teachers: A report of the Holmes Group. East Lansing, MI: Author.

Holmes Group (Undated). Tomorrow's schools: Principles for the design of professional development schools. Executive summary. East Lansing, MI: Author.

Jarvie, I. C. (1972). Technology and the structure of knowledge. In C. Mitcham & R. Mackey (Eds.), Philosophy and Technology: Readings in the Philosophical Problems of Technology, (pp. 54-61). New York: Free Press.

Johnson, J. R. (1989). Technology. Report of the Project 2061Phase I Technology Panel. Washington, DC: American Association for the Advancement of Science.

Johnson, S. D., Erekson, T. L., Dugger, W. E., & Blankenbaker, E. K. (1990). The impact of teacher education reform on preservice technology teacher education. Journal of Industrial Teacher Education, 27(2), 29-47.

Kerlinger, F. N., & Pedhazur, E. J. (1973). Multiple regression in behavioral research. New York: Holt, Rinehart and Winston, Inc.

Layton, D. (1988). Revaluing the T in STS. International Journal of Science Education, 10(5), 367-378.

Lewis, T. (1991). Introducing technology into school curricula. Journal of Curriculum Studies, 23(2), 141-154.

Lewis, T. (1991). Main currents in teacher education: Imperatives for technology teacher education. Journal of Industrial Teacher Education, 29(1).

Lewis, T., & Gagel, C. (in press). Technological literacy--A critical analysis. Journal of Curriculum Studies.

Locatis, C. N. (1988). Notes on the nature of technology. The Technology Teacher, 47(7), 3-6.

Olson, D. W. (1972). Industrial arts: Interpreter of technology for the American school. Man Society Technology, 32(1), 36-39.

Pullias, D. (1992). What is technology education? The Technology Teacher, 51(4), 3-4.

Rapp, F. (1989). General perspectives on the complexity of philosophy of technology. In P. T. Durbin (Ed.), Philosophy of Technology: Practical, Historical and Other Dimensions. Philosophy and Technology Vol. 6, (pp. ix-xxiv). Dordrecht: Kluwer.

Roy, R. (1989). Natural allies--STS and technology education. The Technology Teacher, 48(4), 13-17.

Savage, E., & Sterry, L. (1990a). A conceptual framework for technology education. The Technology Teacher, 50(1), 6-11.

Savage, E., & Sterry, L. (1990b). A conceptual framework for technology education part II. The Technology Teacher, 50(2), 7-11.

Skolimowski, H. (1972). The structure of thinking in technology. In C. Mitcham & R. Mackey (Eds.), Philosophy and technology: Readings in the philosophical problems of technology (pp. 42-49). New York: Free Press.

Towers, E. R., Lux, D. G., & Ray, W. E. (1966). A rationale and structure for industrial arts subject matter. Columbus, OH: The Ohio State University. (ERIC Document Reproduction Service No. ED 013 955)

Warner, W. E. (1965). A curriculum to reflect technology. AIAA feature presentation, April, 1947. Columbus, OH: Epsilon Pi Tau Inc.

Table 1

Principal Components/Varimax Solution
for the Nature of Technology (N=392, 16 items)

	Factor Numbers, Names, and Loadings							
	1*	2	3	4	5	6		
% of Variance Explained	22.0%	13.0%	9.4%	7.8%	7.3%	6.3%	Cum% 65.8	Communality
Item No.								
1	.85							.76
7	.83							.74
8	.53							.54
4	.51							.53
15		.88						.80
16		.88						.81
14		-.46						.68
5			.77					.63
3			.60					.64
2			.57					.65
12				.81				.67
13				.60				.62
11					.72			.59
9					.71			.61
10						-.69		.73
6						.60		.52
Sums of Squares (Eigenvalues)	3.5	2.09	1.5	1.3	1.2	1.0		

* 1 = Applied Science
2 = Method/Process
3 = Praxis
4 = Know-how
5 = Undefined
6 = Undefined

Table 2

Outcome Factors with Related Survey Items[1]
for the Nature of Technology

Item No.	Factor Name and Related Questionnaire Items
	1. APPLIED SCIENCE
1	Technology is applied science
7	Technology is practical science
8	Technology and science rely upon the same modes of thinking
4	Technology, like science, is confirmed by the laws of nature
	2. METHOD/PROCESS
15	Technological problems differ from scientific problems
16	Technological solutions differ fundamentally from scientific solutions
14	Technological inquiry must conform to the scientific method
	3. PRAXIS
5	Technology refers to artifacts (tools or devices)
3	Technology is "doing"
2	Technology is an autonomous sphere of knowledge
	4. KNOW-HOW
12	Technology refers to all human efficient practices
13	Technology refers to capability--knowing how to
	5. UNDEFINED
11	Technology refers to means only, not to ends
9	Technology is neutral, value free
	6. UNDEFINED
10	Technology is art; it is creative expression
6	Technology is distinct from craft

[1] Items listed in descending order according to the size of their rotated factor loadings.

Table 3

Multiple Regression Analysis of Responses
Relating to the Nature of Technology
(Regression Coefficients [Bs] Reported)

Independent Variables	Factors (Dependent Variables) Applied Science	Method/ Process	Praxis	Know-how
ITEA (member or not)	--	-.33** (.12)	-.53*** (.12)	-.28* (.12)
NAITTE (member or not)	--	--	-.30 (.13)	--
Holmes (Affiliation or not)	--	--	-.28 (.14)	--
Location (College of Education or not)	--	--	--	--
Rank (Professor versus Associates, Assistants, and Instructors)	-.33* (.12)	--	--	--
Experience (Years as a university faculty member)	--	--	.02* (.006)	--
Highest Degree Granted (Doctorate and Ed.S. versus Bachelors and Masters)	-.27 (.12)	--	--	--
Teaching Emphasis (Professional versus Technical)				
Multiple R	.20	.16	.38	.14
R-Square (adjusted)	3%	3%	12%	2%
Constant	.84	.44	1.0	.42

Note: Significant T - * $P \leq .01$
** $P \leq .005$
*** $P \leq .0001$
( ) = Standard error of B

Table 4

Means and Standard Deviations for Regression Outcome Factors METHOD/PROCESS, PRAXIS and KNOW-HOW by ITEA Membership

FACTOR	ITEA			Non-ITEA			
Items	M	SD	N	M	SD	N	P
METHOD/PROCESS							
Technological problems differ from scientific problems	3.28	1.20	229	2.84	1.19	134	.0009
Technological solutions differ fundamentally from scientific solutions	3.06	1.18	231	2.60	1.12	133	.0004
Technological inquiry must conform to the scientific method	2.93	1.22	230	3.31	1.25	134	.0041
PRAXIS							
Technology refers to artifacts (tools or devices)	3.49	1.00	232	2.95	1.21	134	.0000
Technology is doing	3.95	.96	232	3.58	1.12	134	.0012
Technology is an autonomous sphere of knowledge	2.95	1.32	230	2.42	1.18	134	.0001
KNOW-HOW							
Technology refers to all human efficient practices	3.57	1.16	230	3.16	1.13	135	.0009
Technology refers to capability-knowing how to	3.99	.87	231	3.90	.96	134	.347

Scale 1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

Table 5

Principal Components/Varimax Solution
for the Subject Matter of Technology Education

	Factor Numbers, Names, and Loadings								
% of Variance Explained	1*	2	3	4	5	6	7	Cum%	Communality
	26.8%	17.1%	8.3%	5.5%	4.9%	4.2%	3.7%	70.4%	
Item No.									
21	.90								.85
20	.90								.84
24	.89								.84
22	.89								.84
23	.89								.87
19	.56								.56
25		.80							.68
26		.78							.63
36		.72							.63
34		.70							.62
32		.64							.54
35		.59							.60
30			.93						.91
29			.91						.86
31			.88						.85
33				.82					.77
37				.82					.78
43					.77				.72
17					.68				.61
38					.58				.63
18					.46				.58
40						.62			.60
39						.61			.65
27						.56			.67
28						.52			.70
44							.82		.72
42							.68		.61
41							.56		.56
Sum of Squares (Eigenvalues)	7.5	4.8	2.3	1.5	1.4	1.2	1.04		

* 1 = Innovative
2 = Context
3 = Traditional
4 = Bio-Related
5 = History
6 = Systems/Processes
7 = Creativity

Table 6

Outcome Factors with Related Survey Items[1] for the Subject Matter of Technology Education

Item No.	Factor Name and Related Questionnaire Items
	1. INNOVATIVE
21	Construction
20	Manufacturing
24	Communications
22	Transportation
23	Power/Energy
19	Structure/Organization of Industry
	2. CONTEXT
25	Socio-political context of technology
26	Moral issues attending technology
36	Social impact of technological change
34	Evaluating technology/technological choice
32	Economic context of technology
35	Social technologies (technologies relating to government, politics, etc.)
	3. TRADITIONAL
30	Metalworking
29	Woodworking
31	Plastics
	4. BIO-RELATED TECHNOLOGY
33	Bio-related technology
37	Technologies relating to food and health (agriculture, food, genetic technology)
	5. HISTORY
43	Biographies of famous inventors/innovators
17	History of technology
38	History of science
18	Structure of technological knowledge
	6. SYSTEMS/PROCESSES
40	Systems theory
39	Production
27	Materials
28	Industrial processes
	7. CREATIVITY
44	Creativity
42	Design
41	Critical thinking/problem solving

[1] Items listed in descending order according to the size of their rotated factor loadings.

Table 7

Multiple Regression Analysis of Responses Relating to the Subject Matter of Technology (Regression Coefficients [Bs] Reported)

Independent Variables	Factors (Dependent Variables)						
	Innovative	Context	Traditional	Bio-Related Technology	History	Systems/ Processes	Creativity
ITEA (member or not)	--	-.46*** (.12)	.46*** (.11)	--	.33* (.12)	--	--
NAITTE (member or not)	--	--	--	--	-.27 (.13)	--	-.27 (.12)
HOLMES (affiliation or not)	--	--	--	--	--	--	.29 (.14)
LOCATION (within College of Education of not)	--	-.37** (.12)	--	--	--	--	--
RANK (Professor versus Associate, Assistant, or Instructor)	--	--	--	-.24 (.12)	--	--	--
EXPERIENCE (years as a university faculty member)	.01 (.006)	--	--	--	--	--	--
HIGHEST DEGREE GRANTED (Doctorate & Ed.S. versus Masters & Bachelors)	--	.31* (.12)	--	--	--	--	--
Multiple R	.12	.29	.23	.12	.23	--	.16
R - Square (adjusted)	1%	8%	5%	1%	5%	--	3%
Constant	-.26	.28	-.65	.32	.89	--	-.49

Note: Significant T - * $P \leq .01$
** $P \leq .005$
*** $P \leq .0001$

( ) = Standard error of B

Table 8

Descriptive Statistics for Regression Outcome Factors
CONTEXT, TRADITION AND HISTORY by ITEA Membership

FACTOR	ITEA			Non-ITEA			
Items	M	SD	N	M	SD	N	P
CONTEXT							
Socio-political context of technology	3.14	.72	231	2.72	.78	132	.0000
Moral issues attending technology	3.24	.73	232	2.96	.90	132	.0016
Social impact of technological change	3.39	.70	231	2.95	.85	132	.0000
Evaluating technology/ technological choice	3.36	.70	230	3.04	.87	132	.0002
Economic context of technology	3.16	.64	232	3.05	.76	131	.14
Social technologies	2.65	.85	231	2.31	.82	132	.0003
TRADITIONAL							
Metal Working	2.52	.87	231	2.92	.85	132	.0000
Woodworking	2.47	.87	229	2.78	.91	131	.0016
Plastics	2.66	.85	231	2.98	.85	132	.0005
HISTORY							
Biographies of famous inventors/ innovators	2.40	.73	230	2.09	.79	132	.0002
History of Technology	3.21	.68	232	2.75	.72	132	.0000
History of Science	2.28	.75	230	2.20	.74	132	.276
Structure of technological knowledge	3.31	.74	232	2.96	.78	131	.0000

Scale 1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree
5 = Strongly Agree