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Introduction

The Journal of North Carolina Technology Teacher Education is a publication through which technology teacher educators may share the findings of current research in technology education. The research reported in the journal may serve to provide a foundation for change in improving the discipline and its practice. Further, the reported research may provide the basis for further in-depth investigation of selected topics pertinent to educational change.

The journal provides contributors with an avenue for refereed publication. The referee process by colleagues assures purity of the research process. However, the journal is not limited to publications that have met all the rigors of the referee process. Referee or non-referee status of each published article will be visibly indicated on the title page preceding the article.

Authorship in the journal is not limited to technology teacher educators. Articles from graduate students and interested persons outside the discipline will be welcomed.

Dr. W. James Haynie, 1989-90 council president, proposed the journal to colleagues in the council, published the first call for papers and established criteria for the referee process. The vision of Dr. Haynie is evidenced in this first publication of technology teacher educators in North Carolina.

This second edition of the journal contains three refereed articles reporting research results on timely topics of interest. Council leadership hopes that each future call for papers will see an increase in North Carolina research activity and in the growth of the journal through reporting of such activity for publication.

Jane M. Smink, Ed.D.
Editor

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(Each article carries its individual numbering system that has not been altered. For that reason, each published article may be located by title page color.)

NORTH CAROLINA COUNCIL OF TECHNOLOGY TEACHER EDUCATORS MEMBER INSTITUTIONS

North Carolina Council of Technology Teacher Educators (NC-CTTE) is a council within the North Carolina Technology Education Association. Purposes of the council are: 1) to provide research pertinent to the discipline of technology and 2) to serve the needs of individual and institutional members.

Member institutions of the North Carolina Council of Technology Teacher Education are:

Appalachian State University

East Carolina State University

Elizabeth City State University

North Carolina A&T State University

North Carolina State University

Western Carolina State University

Identification of Quality Characteristics for Technology Education Programs in North Carolina

Aaron C. Clark, Ed.D.

Department of Mathematics, Technology, and Science Education

North Carolina State University

(Refereed Article)

IDENTIFICATION OF QUALITY CHARACTERISTICS FOR TECHNOLOGY EDUCATION PROGRAMS IN NORTH CAROLINA

by Aaron C. Clark
North Carolina State University
Department of Mathematics, Science, and Technology Education

Abstract

The purpose of this study was to identify those quality characteristics that contribute to a quality technology education program in North Carolina. These indicators of quality may be used by educational leaders throughout the state. The indicators developed in this research study were validated through consensus drawing measures from a panel of experts in the fields of technology education, vocational administration, and teacher education. The process and procedures used to develop and validate this information was a conventional Delphi process. Round one of the Delphi process solicited information about what were the quality indicators of a technology education program from an expert panel that consisted of technology teachers, vocational directors, and a teacher educator within the state. Once this information was obtained, round two had the expert panel to rate these indicators and in round three rank each indicator within a category. Round four validated those indicators kept from previous rounds through the use of a Chi Square Statistical Test. Both nonparametric and parametric statistical measures were used through the duration of the study to show that consensus was being achieved through the different Delphi rounds.

Conclusions made from the study include a listing of quality indicators for technology education programs in North Carolina which can be used to assess whether or not quality is being achieved within a program. The study represents one significant step in the long process towards establishing quality technology education programs within the state. This will help to lead technology education programs within the state into the next century with an emphasis of consistent acceptance of change and program improvement.

Introduction

Technology education is one of eight vocational program areas that offer elective competency-based courses to students attending public school systems throughout the state of North Carolina. The mission and purpose of vocational education is to empower students to become effective participants in a global economy and to develop into world-class workers and citizens (North Carolina State Department of Public Instruction, 1993). Technology education conforms to this mission by offering students a means to gain an appreciation for and an understanding of technology. Through the study and application of tools, materials, and processes, students develop their ability to think critically and solve problems (North Carolina State Department of Public Instruction, 1992). The curricula focus is on four main systems: communications, transportation, structures, and manufacturing. As a result, students learn how to apply abstract ideas and develop an understanding of the relationship between technology and concepts in mathematics, science, communications, and social studies. A sample of topics within the four systems include: complex tool usage, experimentation, system modeling, safety, application of academic concepts, technological assessment, and team building. North Carolina offers thirteen courses which allow middle school and high school students to accomplish the outcomes of technology education. These outcomes are as follows: "Know and appreciate the importance of technology; use tools, materials, processes, and technical concepts safely and efficiently; adjust to a changing technological environment and adapt to those forces that influence the future; develop problem-solving and decision-making abilities using human and material resources, processes, and technological systems; develop creative abilities, positive self-concepts, and individual potential in technology, thereby preparing themselves for life-long learning in a technological society; make informed career choices; and become a more sophisticated consumer of the goods and services of a technological society "(North Carolina State Department of Public Instruction, 1992, p. 59). During the 1994-1995 school year, approximately 58,179 North Carolina students at both the middle and secondary levels took one or more of the 13 courses offered in technology education. Approximately 20,711 of these students were in grades nine through twelve (North Carolina State Department of Public Instruction, 1994).

Statement of the Problem

Since its beginning in manual training, technology education has continued the process to establish and provide indicators of quality within its curriculum. For more than 25 years, the process of establishing standards or outputs has been a major area of focus at the national and state levels (Dugger, W. E., 1988). One aspect of this movement has been the establishment of a foundation of standards which the profession can use to attain quality for the discipline area and to continue towards excellence within the teaching profession. Once the assessment criteria is established, a benchmarking process can begin by first identifying those characteristics that define a technology education program of excellence (Dyrenfurth, Custer, Loepp, Barnes, Iley, and Boyt, 1993; World-Wide Education and Research Inst., Salt Lake City, Utah, 1982). Efforts within other states, and the Standards Project currently being conducted at Virginia Tech (Technology for All Americans Project, 1995), will aid in this endeavor to establish assessment benchmarks for the profession (Education Commission of the States, Denver, CO., 1992).

Other than VoCATS, North Carolina does not have standards established beyond its curriculum components or have identified quality indicators for a model that can be used to assess whether technology education programs throughout the state are meeting statewide curriculum goals and objectives' (D. Shumate, personal communications, October 3, 1995). The VoCATS process only identifies curriculum outputs by pre- and post-testing students taking a particular vocational course, it does not review the total program. Therefore, a need existed within the state to define characteristics of programs with which one can assess program quality so that benchmarks for the discipline can be established (D. Shumate, October 3, 1995; T. Shown, personal communications, October 12, 1995). The problem that of study involved the lack of adequate program quality characteristics used to determine whether goals and objectives are met. Therefore, the purpose of this study was to identify those quality characteristics to assess technology education programs in North Carolina.

Rational for Research

"Technology is a body of knowledge, a field of study, a substantive curriculum, and a pervasive force relevant to all aspects of human endeavor. Technology competence means more, far more, than learning with or about computers or the ability to use any device, machine, or tool" (Zilbert & Mercer, 1992, p. 12).

Nearly every aspect of a person's life is touched by the products or by-products of technology. It has become synonymous with change, and although these ever changing technologies have created problems, they have also "provided the means by which this area of education (technology) can be legitimately presented" (Gloeckner, 1990). The field of technology education is to supply students with this needed knowledge about technological change so that they can make good decisions about the use of technology in their everyday lives and careers.

The nature of this study was to identify those characteristics which constitute quality in a technology education program and may be used to assess technology programs throughout the state of North Carolina on whether or not quality is evident in each program. Henak (1992), indicated that one area that needs to be researched in our profession of technology education is quality. He stated that quality needs to be a consideration in the learning environment for all students that take technology education courses. Henak declared that quality learning in a technology education program comes from the content, learning process, experiences, and growth opportunities offered to the students.

Why does no assessment model currently exist for measuring quality in a technology education program in North Carolina? A simple rationale for the resistance to evaluation was that it becomes "disruptive, innovative, and a vehicle for change" and requires extra effort (Armstrong, 1985, p. 2). If North Carolina is to move ahead to higher quality technology education, then some form of assessment needs to occur. One rationale for the need of assessment comes from the World-Wide Education and Research Institute in Salt Lake City, Utah. This institute said, in an end of year project report titled Quality Indicators for Vocational Education (1982),

> "it is more than just curiosity that makes the conscientious teacher or school administrator want to know how well he -- or his class, school, or school district -- is performing as compared to others. Parents, too, want to know how well their children are progressing and how good the schools are. Both groups want to know whether there must be greater efforts made, better programs adopted, newer equipment obtained, etc.."(World-Wide Education and Research Institute, 1982, p. 3).

Administrators and teachers are now being held accountable for how money is spent and what is being taught in the classrooms. If a process exists to identify that a program is of quality, then accountability can take place and more resources can be given to the program.

Another rationale for identifying quality characteristics for technology education in North Carolina came from section 115 of the Carl D. Perkins Act of 1990. In this act, it is mandated that "each state board receiving funds under this Act shall develop and implement a statewide system of core standards and measures of performance for secondary and post-secondary vocational education programs" (Roberts-Gray, 1992, p. 1). Although this research project is not to replace existing measures for the North Carolina State Department of Public Instruction (NC-SDPI), it's mission was to enhance NC-SDPI efforts in establishing core standards and develop higher quality standards for vocational and technology education programs throughout the state.

A third rationale for this study was the belief that it is best to assess the outcomes of a technology education program as they are being enhanced (Savage, 1993). Programs that are growing and going through change need to establish an assessment process in order to enhance the existing program and build benchmarks so that students can be taken to higher levels of proficiency (Educational Testing Services, 1992). Currently, educational reform is being considered within the state, and program assessment with the setting of benchmarks are two of the priority concerns for reforming education (Johnson, 1992) and are primary goals for leaders in North Carolina.

Finally, technology education is setting new standards for technology programs across the country and therefore, "new forms of assessment will be needed to determine the quality of education provided in schools, districts, states, and the nation as a whole" (Johnson, 1992, p. 8). Nationally, as the profession of technology education is setting standards, an evaluation process is needed in each state to analyze programs so that questions about the quality of a program can be answered (Federal Coordinating Council for Science, Engineering, and Technology, 1993). But, if responsible change efforts are to be made to establish quality in a technology curriculum it "must include structures for intentional, objective, and critical assessment in order to benchmark the process" (Dyrenfurth, Custer, Loepp, Barnes, Iley, and Boyt, 1993, p. 57-58). Therefore, the purpose of this study was to identify quality characteristics, and from these characteristics, develop a document in which quality standards can be established and benchmarking started for each program involved so that each can strive towards excellence in the technology education curricula offered in North Carolina.

Research Methodology

The main purpose of this study was to answer the research question that asked what categories and quality indicators would be selected and used in assessing technology education programs within the state? The procedures for the research study began with a proposal for conducting the study and a review of literature to acquire data gathering techniques and information pertinent to the subject. The study used a Delphi technique for identifying the quality characteristics for a technology education program in North Carolina. Upon completion of the Delphi process, the quality indicators were formulated into an instrument for assessing quality within technology education programs for North Carolina.

The Delphi process started by having administrative units within educational areas throughout the state nominated names of candidates to be selected for the panel. The panel consisted of technology teachers nominated by state vocational directors, technology teacher educators nominated by departmental chairpersons that offer a degree in technology education within the state, and vocational directors nominated by consultants from the State Department of Public Instruction who dealt directly with technology education related areas. The expert panel consisted of 19 technology education professionals proportionally representing each of the three categories mentioned above with a total of 15 technology teachers, three vocational directors, and one technology teacher educator. The number of members representing each of these three areas were directly proportional to the total number of individuals within the state who could have been selected for the panel and the percentage each area makes up of the total number of potential panel members. Vocational directors were asked for one name of a technology education teacher they would suggest for the panel from their Local Education Agency (LEA). The director could have suggested someone from another LEA if no one met the minimum criteria that each director was to use in determining which technology teachers in their LEA met the criteria standards set by the researcher. The North Carolina State Department of Public Instruction consultants for areas directly related to technology education were asked to nominate six names of vocational directors within the state that each consultant felt were quality candidates for the panel to represent the administrative areas of technology education. Technology teacher educators were selected for the panel by soliciting a teacher educator name from the chairpersons at the different colleges and universities within the state that offered a technology education teacher education degree. Upon receiving names of teachers, administrators, and teacher educators, those names mentioned most often were included in the expert panel and stratified by telephone area code so that all regions within the state were represented on the panel. The remaining names nominated for the panel were stratified by area code as well and randomly selected in order to be asked to participate on the panel. Once the expert panel members were selected, a phone call was made to each person selected to indicate whether or not they wanted to participate in the Delphi process. After the expert panel was established, a review panel of three members was randomly selected from the list of names not selected to be on the expert panel. The review panel consisted of one representative from the technology teachers nominated, one member from the list vocational directors, and one from the list of technology teacher educators not selected for the expert panel. Once the review panel members were selected, notification was given to each person selected to indicate whether or not they want to participate in the process to approve all modifications and materials prior to sending the materials to the panel of experts.

The instrument for round one of the Delphi process was developed from information found in the review of literature and personal interviews with professionals in the field of education. Examples of categories and quality indicators were established and placed in a survey instrument to show the operational format in which the categories and indicators were to be written, and to suggest some possible starting areas. Once the document was approved by the review panel, the instrument was sent to the expert panel. A letter was also sent to panel members after two weeks to remind the panel members to return their responses. Results from round one were tabulated, with like indicators and categories collapsed together.

Round two of the Delphi process included the rating of those indicators from round one. The instrument was developed and sent to the review panel for verification before being sent to the expert panel. The indicators were placed in random order under their corresponding categories. The round consisted of rating each indicator from the previous round. Indicators with a mean of 3.01 or higher were kept for the next round. A One Factor Repeated Measures Analysis of Variance (ANOVA) statistical test was conducted on the category titles to see if any statistical significance could be seen in the rankings of categories through the collected rated means of indicators for each particular category in this round.

Round three consisted of ranking the information gathered from round two. Every panel member was asked to rank, in order of priority, each quality indicator within each category. Once the instrument was approved by the review panel, it was sent to the panel of experts. A Spearman's Coefficient of Correlation test was conducted on the data collected from rounds two and three to show correlation between the statistical ranking and the actual rankings obtained in this round. The test was also applied to the actual rankings and their medians from this round to show the correlation of information found in this third round of the Delphi study to show that consensus was developing through the Delphi process. A high correlation between both sets of data indicated that the consensus building process was working. Indicators kept from this round were those that ranked in the upper 50 percent for a category. These indicators were kept because they were ranked highest by the expert panel, and therefore, were the indicators with the highest consensus for a given category.

Dephi round four presented the quality indicators in ranked order to the expert panel and solicited final approval of the quality indicators. Each expert panel member was asked to approve the final outcomes as established from round three of the Dephi process. Once the review panel approved the final form, the fourth and final round was mailed for approval from each of the expert panel members. Expert panel members were asked to accept or reject each indicator kept from round three. Once this data was collected, a Chi Square Test was conducted to show indicators that have met consensus through the Delphi process and were kept in the final list of indicators.

Statistical information drawn from the Delphi process included: descriptive statistics from each round, non-parametric statistics comparing answers given from different representatives of the expert panel, and overall statistical comparisons between the different rounds of the Delphi process. The Spearman rank correlation coefficient, and chi-square were nonparametric statistics used to measure and analyze the data gathered for this Delphi study (Daniel, 1978; Gibbons, 1976; Siegel, 1956; Sprent, 1993). The One Factor Repeated Measures ANOVA test was a parametric test used to see if the overall mean ratings for each category's indicators were significantly different from one another.

Once the final approval was given for each indicator and category, the information was considered validated by both the panel of experts and the review panel.

Conclusions

Listed below are the indicators and categories kept from the final Delphi round of this study, these are considered validated through the use of experts in the field of technology education and the research procedures used within this study.

Philosophy and Mission of Program Category:

The program objectives address the need to teach the application of technology for the present and future needs of society.

The philosophy and program objectives include teaching students the importance of using knowledge, materials, tools, and machines to solve problems by producing products.

Technology teachers are actively involved in developing the philosophical and/or mission statement for the program.

The philosophy and program objectives address the need to continually update and revise the curriculum.

Instructional Program Category:

Course content is developed from course competencies/enabling objectives and utilizes approved curriculum guides, courses of study and professional resources.

Course content is allowed to develop and to experiment with new technologies and areas.

Course content is affected by the perpetual evolution of technology and society's interaction with that technology.

Student Populations Category:

Technology education activities are provided for all students without bias toward gender, ethnic background, achievement, handicap, or disadvantagement.

All students are provided guidance about technology education course offerings at their school.

All population types are represented in the technology education program.

Program Requirements Category:

Sufficient funds are budgeted for equipment and facility improvements to accomplish course objectives.

Administration presents the attitude necessary for growth and development of technology education programs.

The maximum number of students per period is appropriate for class population (special populations, etc.) and appropriate for the type and kind of instructional activity(ies) conducted.

Administration is knowledgeable of the need to continually update the technology curriculum.

Safety and Health Category:

Technology teachers prepare and teach appropriate lessons on safety.

Students participating in technology education classes are required to complete a written safety test on applicable equipment with 100% success.

Professional Development Category:

The technology teacher is provided adequate time and finances to attend at least one state sponsored workshop or function.

Adequate funding is provided for technology teachers to participate in local, state, and national professional development according to local policy and procedures.

The technology teacher participates in staff development activities that lead to the correlation of technology education with other related academic and vocational disciplines.

Facilities/Equipment/Materials Category:

The technology presented is applicable to the present and future workplace.

The appearance and arrangement of the laboratory reflect the mission and philosophy of the program.

The technology offered in the program is up-to-date with current technological needs.

Public Relations Category:

Teachers and students maintain a high state of visibility through the promotion of class and student activities as a public relations strategy.

Students promote and support technology education programs through involvement in activities, including NC-TSA or Career Exploration Clubs of North Carolina.

Business and industry actively communicate with the local schools.

Summary and Recommendations

The research study asked what categories and quality indicators were selected and could be used for assessing technology education programs within the state. This research question was examined through the Delphi process conducted in this study. In the four Delphi rounds conducted within this study, a panel of experts in the fields of education and technology education identified quality indicators through a consensus building process.

The Delphi process used for this study validated the quality indicators. Validation was achieved within the study through the use of consensus-drawing processes using experts from the field of technology education within the state. Stratification measures used for locating expert panel members helped assure that the indicators and categories represented consensus from across North Carolina. The statistical tests applied during the research process for this study validate that consensus was being achieved during the study and that consensus-gathering strategies used within the study were working.

Recommendations for future research in this area includes the need for this study to be replicated using other professionals in the fields of education and technology education at both the state and national levels. A comparison of data would aid the research in establishing final consensus on quality indicators at both the state and national level using these different experts. Also, additional research is needed in developing an assessment strategy and model for assessing quality in a technology education program within the state as well as at the national level. Finally, validated instruments to indicate quality in a program need to be developed to assess quality in technology education programs at both the state and national levels.

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An Identification of Digital Image Processing Competencies for the Undergraduate Graphic Arts and Imaging Technology Curriculum

John R. Craft, M.A.

Department of Technology

Appalachian State University

(Refereed Article)

An Identification of Digital Image Processing Competencies for the Undergraduate Graphic Arts and Imaging Technology Curriculum

John R. Craft

Appalachian State University

INTRODUCTION

This article is research currently in progress under the direction Dr. Richard E. Peterson at North Carolina State University. It is the intent of this research to identify digital image processing competencies in an effort to improve course content and address the technological changes that are continuously affecting the technology graphic arts curriculum.

The impact of the "digital revolution" has had an enormous effect on society and in particular the printing industry. Digital image processing has caused a paradigm shift in the technology of printing which has affected the printing industry at a faster rate than previous printing and photographic technologies. For over fifty years, before the development of digital imaging, the photographic process was the dominant technology for the printing industry (Kapaun, 1997). With digital imaging, however, the printing process has changed within a mere five years (Kapaun, 1997). Since 1990, photographic and printing technologies have advanced to the digital process more rapidly than originally expected by the printing industry (The National Printing Skills & Knowledge Standards Project, 1996). The effect of this shift to the digital imaging process has led to the need for the constant upgrading and retraining of individuals. Lewis (1996) articulated the impact of new electronic technology, specifically its affect on the printing industry as it transforms the workplace from a traditional manual prepress process to a digital image process, in which complex color separation and image assembly are done completely from a computer workstation. Technology educators, particularly those that teach graphic arts, continually need to educate themselves about the emerging technologies and decide what to include in the content of the technology graphic arts curriculum. Technology curricular programs such as Graphic Arts and Imaging Technology are newly implemented to reflect the transition from conventional printing and photographic processes to computerized digital imaging processes .The identification of competencies becomes necessary in providing educators teaching about new technologies as a means for satisfying expected needs of industry. Knowing about specific competencies can provide educators with resources in organizing and establishing content for courses that utilizes contemporary technology as a precursor for entry into a career or preparation of individuals for a functional role in a technically oriented society.

The Impact of Digital Imaging on the Printing Industry

Printing Industry Before Digital Imaging

The United States has been faced with global competition as the result of the change to the digital technology (Jorgensen, 1996). To remain competitive and maintain the lead in managing new technologies, industries such as printing recognize the need to effectively prepare existing or potential employees for a high performing role in a rapidly changing workplace. It was recently reported by the Printing Industries of America that digital technology would reshape the printing industry (Mandel, Hauser, Carney, Gonzalez, & Bose, 1994). Daniel Burrus (1993), a professional technology forecaster and consultant to multinational corporations, has identified digital imaging as one of the core technologies for shaping the future. With the design and production of high speed desktop computers equipped with large capacity memory and data storage, digital image processing is becoming more appealing and accessible as a tool for photo illustrators, graphic designers, and others involved with printed production.

Printing Industry Before Digital Imaging

Before the digital revolution that began with the introduction of desktop computers appearing in printing companies during the early 1980s, most of the artwork was prepared by the graphic arts department in a printing company or design house equipped with phototypesetting equipment. The conventional printing production process required the use of expensive photographic film and plates to insure quality (Atteberry, 1984). The responsibilities between professionals creating the artwork and page producers were not fully unified before the digital imaging process (Romano, 1996). Artwork generated by the art professional required many pieces such as overlays with handwritten instructions or notes in the margin serving as a means for communicating to the printers. After creation of the design, the graphic artist relied on the expertise of the commercial printer to provide the proof—which would serve as a preliminary preview of the artwork before it went into printed production (Romano, 1996). The complexity of color production before digital imaging required more stages of production taking longer to get to a full color proof so that the design professional could make changes. The immediacy of a graphic artist sending a computer generated layout file to another site complete with color information radically changed the printing process. Having access to electronic design tools, the art designer can actually get an idea of color layouts before sending them to the printers.

Before the transition to digital technology, phototypesetting presented several drawbacks to the printing industry. The tremendous effort to find and train individuals for skills in phototypesetting and multicolor page layout preparation was quite costly to printing companies. An example of the complexity involved in learning to set type on a phototypesetter would be the coding system that appears on the display terminal of the typesetting unit. Typesetters not only had to develop skills such as keyboarding, but also had to understand foundational information such as the optical system, the printer's measurement system, and the photographic system. Another disadvantage was the hazardous waste by-products created by the phototypesetting process. Fumes are generated by the photochemical process and can cause corrosion to metal as well as human respiratory problems. All of these problems have helped cause the decline of the phototypesetting process.

Impact of Desktop Computers

Further edging out and creating an extension of the use of the phototypesetting process, the desktop computer was introduced as a workstation for printing companies during the 1980s. It was reported in the "Bridging to a Digital Future (PIA, 1994)," that complex electronic images have expanded the market for other production options other than printing on paper. The shift to the establishment of electronic prepress departments where graphic design professionals have more control over issues such as color proofing without the design leaving the department is attributable to the development of the desktop computer. Desktop computers connected to laser imagesetters have also streamlined the production process, making it possible to produce high quality photographic images in addition to type printed out on paper, film or plates. Major breakthroughs such as the development of Adobe Systems' Postscript printer description language have become a standard for imagesetters and laser printers producing higher resolution images that has rivaled the phototypesetting process. The printer description language has significantly contributed to the digital revolution just as desktop computers, laser printers, digital cameras were impacting the printing industry. At about the same time that printer description languages became available, the desktop computer equipped with powerful and professional level digital imaging tools became more affordable thus making it possible for the nonprofessional public to explore using these tools as a way to generate their own publication layouts or improve photographic images. The person with a combined computer know-how and photographic background has an advantage in using digital imaging technology since postscript printer drivers were supplied with imaging processing or page layout programs.

Newspaper and magazine production became revolutionized by the digital process since entire layouts, including color, fonts, and photographic images could be transmitted regularly (Atteberry, 1984). National newspapers such as USA Today make use of satellite transmissions to allow for last minute changes in providing news coverage which was made possible by digital image processing (Atteberry, 1984). This ability of the computer to control and manage the disbursement of printed information has made it a driving force in keeping the printing industry in United States competitive in the global marketplace (Zeffane, 1992; Jorgensen, 1996).

Improvements in computer technology have had a further consequence of changing not only the printing industry, but also the field of photography. Just as desktop publishing has revolutionized typesetting for the printing and publishing industry in 1985, electronic imaging is doing the same for photography. The transformation of the conventional camera and darkroom to computerized digital image processing (Krejcarek, 1997) is expected to eventually replace silver-based film emulsions used to generate images with conventional photographic equipment and materials (Schlowsky, 1992). For 150 years, the photographic process was unchallenged as a means for producing photographic images. Photographers or darkroom technicians, specifically those that worked in the area of process photography, relied on conventional methods of photographic chemical processing and silver-based film emulsions to generate images. Now the technology of desktop computers has made it possible for sophisticated digital image processing software to simulate photographic darkroom effects without having to go into the darkroom.

Impact of Software

Sophisticated software programs are continuously being improved to imitate the tools of the traditional photographers. Traditional darkroom processes such as burning and dodging, masking, color correction, spotting (to remove dust or scratches) and other graphic control processes are included in the design of image processing software. As a result of these improvements, greater demands on the design of hardware, e.g., memory, faster processors, and storage capability, are affected by software design. Whenever new software versions are released into the market, they not only affect considerations for upgrading the hardware, but also the personnel who will have to use it.

Imaging software is more accessible to technology education students and the general population as the evolution and proliferation of personal computers becomes woven into the structure of a modern society immersed in the Information Age. Although the availability of imaging software is an option to the consumer, software designers have set their own standards in defining tools and processes involving the manipulation of photographic images that are converted into digital information. Until the mid 1980s, the capabilities of producing high quality scanned images, were only available to large companies able to afford sophisticated image processing equipment. Now, the developments in the design of desktop computers and software have made it possible for nonprofessionals with a little capital desiring to produce high quality documents to have direct access to some of the most powerful tools for scanning and image editing.

Even though the public has access to the tools of the professional graphic artist by using digital imaging software, being properly trained to meet the printing industries demands for quality as a means for competition in a global community is just as necessary as it was before its availability. Because of all the improvements in the technology of computers and software, the printing industry is changing prepress operations to digital imaging. Over 50% of printing companies in the United States have converted their manual paste-up departments to digital prepress departments utilizing computers as workstations for the production of publication layouts (PIA, 1995). This enormous change makes training to meet the needs of the industry crucial. Technology education must strive to fill those needs by updating its curriculum and skill standards.

The Impact of Digital Imaging on the Technology Education Curriculum

Before Digital Imaging

The printing industry's shift to digital image processing has greatly affected educational programs that have used the traditional industrial model for graphic arts education. Before the shift to digital image processing, students enrolled in the technology education curriculum, and learned about process and continuous tone photography as part of the graphic arts curriculum, a foundational course of study that was included in the original manual arts curriculum. Process photography enabled students to generate line negatives that were crucial in the production phase of printing production. The line negatives were used along with masking sheets to produce the plate for offset lithographic printing. Computers now have the capability to digitally produce the equivalent of a line negative that is of better quality, more controllable for stability, as well as economically and environmentally advantageous.

Graphics Arts as a discipline has its roots in the traditional manual arts curriculum (Bennett, 1917; Miller & Smalley, 1963). Before digital imaging, prepress operations involved the labor intensive use of phototypesetters and process cameras. The technology education curriculum in graphic arts centered around the teaching of these skills. Since the relevancy of digital image processing to the instruction in graphic arts is more concerned with the preparation of images for printed duplication, this is what differentiates graphic design curriculum found in most art departments from the graphic arts curriculum that is a part of the technology education curriculum. It was Charles Bennett's (1917) belief that graphic arts is a significant course providing students realistic knowledge as experienced in harmony with industry (Miller & Smalley, 1963). During Bennett's time, graphic arts was associated with various forms of drafting. Graphic arts was classified among five fundamental manual arts processes including mechanic arts, plastic arts, textile arts, and book–making arts. Printing was part of the book-making arts. As graphic arts evolved with technology, printing became part of its classification.

Impact of Computers

The appropriateness of students learning about image processing is fitted to the current trend in the use of computer technology throughout society in the United States. The transition from the "Industrial Age" to the "Information Age" has caused the focus and philosophies of traditional industrial arts programs to shift from an emphasis on "hands-on" experience to a more conceptual and virtual area of learning. This development is in-line with the burgeoning movement of the Information Age that is present in the domain of technology education. Where desktop publishing courses have become part of a trend as an offering in the university level technology education curriculums, image processing is the next wave affecting the instruction of traditional graphic arts and photography. Competencies that students are expected to possess are dependent upon many factors included in the structure of the course or the background and expertise of the instructor charged with the content of the course. Most of the university level technology educators come from the traditional industrial arts curriculum. This was before mandated changes imposed by departments of instruction in states having industrial arts curriculums converted to the technology education curriculum during the early 1990s.

Another example of the change to the technology education curriculum is the emergence of the computer as a tool. The functional aspects of digital imaging supports the working knowledge that students have concerning the computer as a tool for improving images. For instance, knowing how to correct color shifts in photographic images requires more effort in the photographic darkroom as well as expense for the photographic materials. Students can understand color correction concepts and make changes by using computer software tools to enhance color deficiencies in images. Using digital imaging as an efficient problem-solving tool, educators can not only teach a specific skill but also use digital image processing software to provide experiences on a computer screen that imitate traditional photographic darkroom concepts.

An advantage for schools offering digital imaging in the technology education graphic arts curriculum is providing students with access to sophisticated software for creating printed materials. The appeal of this form of computer software for students of diverse educational backgrounds makes it possible for students to receive computerized instruction in a nonthreatening programming language with a greater opportunity for successful outcomes. These outcomes are measures that are identifiable as competencies that enable the learner to function effectively in an information dominated society. To function effectively in an industry dependent on higher skill performance, students receive the quality of training that prepares them for entry into a competitive workforce (SCANS, 1992). The social forces that influence the curriculum for graphic arts are affected by the trends in the business world—this being the computerization of society.

Another advantage digital imaging creates is the use of graphical environments, such as Microsoft Windows or Macintosh Operating System, to provide the learner with a set of tools that make learning about computers a nonthreatening or intimidating experience. President Bill Clinton, in his State of the Union Address (1997) expressed the importance of being computer literate. Bill Gates, founder and CEO of Microsoft, also shares with the President the vision and goal of a computer in every home. The popularity of computers containing graphical environments is indicative of the appeal computers have as a tool for home or the workplace among consumers. For students, learning to use computers provides access to a set of electronic tools that goes beyond the boundaries of the mechanical typewriter. For instance, technology graphic arts students are able to expand their knowledge of color theory by seeing color models appear on a computer high resolution monitor.

Impact of Digital Imaging on Photography Curriculum

Digital imaging's effect on the technology education curriculum has not only changed graphic arts but also the area of photography. Schools that offer traditional photographic curriculums are making the transition from conventional silver-based photographic print technology to the computer digital form of photography (Foss, 1992, p. 32). Schools with reputable photographic programs such as the Rochester Institute of Technology have established an Electronic Photography Lab. Courses titled Electronic Imaging are included at colleges and universities to enhance graphic arts, as well as photography programs (Davidhazy, 1993). Educational institutions, from the high school level to the university level, are accepting digital imaging as a viable course.

Photography is dependent on silver, used as an ingredient in film, as a means for generating high quality images. To continue and maintain traditions of famous photographers such as Joseph Nicéphore Niépce, Louis Mandé Daguerre, Ansel Adams, Jerry Ulsmann, Man Ray and Annie Leibowitz, schools with computers have in position unique electronic tools to offer photography without having to be concerned about building darkrooms, a major requirement for silver-based film emulsions. Students can learn about lighting and composing concepts on the computer before using an actual camera and exposing film to minimize waste of silver-based film. With the digital darkroom of a computer workstation, images can come from a digital camera, scanner, or other electronic imaging device.

Concerns for Teaching of Digital Imaging

Digital imaging not only creates for technology education many advantages but also drawbacks. Maintaining software revisions becomes an expensive part of keeping laboratories up-to-date. To produce high quality images that do not appear as "laser crud", there has to be support that addresses the budgetary needs of digital imaging instruction. As students prepare for careers in businesses and industries requiring computer experience, the demand for courses containing relevant computer content is increased. For educators, this growing demand presents a set of problems in keeping pace with the changing computer technology. Unexpected changes to digital imaging hardware and software create a problem to an existing curriculum. Having the time to "warm up" to the changes in operating environments, software revisions, or new hardware components requires time that is not built into the design of an established curriculum. Seen as a barrier to printing education programs, the expense of putting state-of-the art technology in the classroom has always posed problems to graphic arts educators trying to stay current and meet the needs in preparing a qualified workforce (Williams, 1993). With the rapid changes to computer technology, educators and curriculum developers are finding it difficult to make the transition to new technology as budget restraints and program cuts are occurring at all levels of education. The flexibility in the design of a curriculum has to allow for the emergence of new technologies.

Although technology education has had troubles in keeping up with rapid technological changes, it is recognized that computer courses are necessary to prepare students for skills in a computer driven society (United State Department of Education, 1996). Image processing does give students a range of skills when working in computer graphical environments and is increasingly offered in technology education curriculums. While computer instruction is vitally important in technology education, competencies need to be defined in order to shape computer course instruction. Other researchers have identified the importance of computer competencies for business and industry (Walker, 1992). To make this determination of competencies, experienced professionals or experts must provide assistance to educators involved in the design of curricula that reflect new and emerging technologies. For technology education courses, advisory boards provide guidance by recommending relevant tasks or job objectives that would better prepare students for a functional role for future employment.

The United States' businesses and industries recognize the need for skill standards as necessary to compete globally. European nations have skill standards for workers and have found it advantageous in providing a quality workforce (Jorgensen, 1996). The concern of businesses and industries for having highly qualified, trained personnel has generated the National Skills Standard Movement in an effort to define skills for schools. One way in which the need for the establishment of skills and competencies can be addressed is to conduct a study to identify competencies needed to effectively teach students about using computer hardware and software for digital image processing as a means for preparing for the highly technical demands of the printing industry.

Need for the Study

Rapid change is a challenge for anyone involved in the design and development of the curriculum (Lauda & McCrory, 1986). This especially true in technology graphic arts education. Improvements in the technology of image processing are frequent with changes occurring quarterly. These frequent improvements create a need for establishing necessary competencies which will allow the technology graphic arts educator to prioritize the plethora of information that is available about digital image processing. Once competencies are identified, then technology graphic arts educators can effectively design a curriculum that can prepare students to succeed as they prepare for a technically demanding industry.

To effectively prepare students to successfully function in a technological society, specific competencies must be identified (Walker, 1992). As noted by Schubert (1985, p.1), the curricular question, "What is worthwhile for the student to know?", should be answered not only by educators charged with designing the course but also with experts utilizing digital technology in the graphic arts industry. Curriculum design at any educational level must address the issues of technology as it prepares students for the workforce. With the emphasis on schools keeping up with emerging technologies, educators must consider curricular designs that effectively and efficiently prepare students for the future (SCANS, 1992).

Walker (1992) defined the competencies for a segment of computer instruction, desktop publishing, in the business world. The more computers and software become tools for the workplace, the more studies that identify competencies become necessary. This study will assemble and survey a panel of experts so a list of competencies can be developed for digital image processing.

STATEMENT OF PROBLEM

It was reported by American Printer (Roth, 1995; Ferris, 1996) from a survey of over 400 graphic arts companies, that finding qualified employees with appropriate computer experience is becoming more of a challenge. One finding of the study indicated that employers placed a higher importance on employees' knowledge of the application of page layout design concepts and the functionality of preparing full color work for press production than understanding the mechanics of computer functions. Gattiker (1992) states that changes in technology are happening so quickly that companies have lost sight as to the nature of skills needed (Gattiker, 1992). Companies are more concerned with prospective employees' knowledge of computer hardware and software without regards to the specificity of skills that may fit within the scope of the company and the nature of its business (Gattiker, 1992). These two differing opinions have caused confusion in the printing industry's expectations of what students graduating from a 4-year institution should know. Technology education in the graphic arts curriculum needs specific competencies defined so educators can know what specific skills to teach. The problem of this study is to determine the digital imaging competencies that are recognized by experts as essential to the study of electronic imaging as a discipline of graphic arts.

THE PURPOSE OF THE STUDY

It will be the purpose of this study to identify specific competencies that will be used to develop undergraduate curriculum in digital imaging as a part of the technology education in the graphic arts curriculum.

METHODOLOGY

When establishing a new course or revitalizing an existing one, the advice of technical experts should be sought since they have knowledge and skills that are important as resource (Clark, 1989). The input of an authoritative group can provide guidance when preparing the content of the curriculum. The Secretary's Commission on Achieving Necessary Skills, established by the United States Department of Labor prepared a document to "help the American Workers prepare for the future—securing a place in the future workforce" (SCANS, 1991). The advice from experts establishes guidelines for existing workers or competencies workers are expected to know when coming into a company.

The identification of digital imaging competencies will assist technology educators in developing relevant digital imaging curricula that will satisfy the needs of the rapidly changing printing industry. Obtaining expert advice from professionals will contribute to the design of an effective digital imaging curricula. Since digital imaging is recognized as a technology that will revolutionize the printing industry, its role in education must be addressed. Getting experts involved in deciding competencies provides the technology educator with a direction in which to lead students. Technology educators must convey that the purpose of the digital imaging course goes beyond the study of conventional photographic and printing curriculums.

The area of prepress technology, where digital image processing is applied, is of particular interest to the printing industry. The scientific community recognizes the importance of digital imaging as a source for increasing the definition of images for analysis (Firebaugh, 1993, p. 23). For the technology educator, the use of digital imaging is more practical as a means of teaching conceptual practices as performed in the graphic arts industry. Technical experts in the digital image processing field can provide insights experiences that are appropriate at the university level. The use of the Delphi to identify the competencies permits the educator to make course content decisions that go beyond the ability of what Clark (1989) describes as being an "unconsciousness competence" (p. 8). Although the educator may be an expert, he or she may be blind by being overly familiarized with the subject matter that specific and important details that would guide students to a successful mastery of the subject would be overlooked.

Using the Delphi

To identify digital image processing competencies appropriate to graphic arts instruction in the technology education curricula, the Delphi method of research was chosen. Delbecq, et al. define the Delphi technique as being a group process which utilizes written responses as opposed to bringing individuals together (Delbecq, Van de Ven, & Gustafson, 1986, p. 83). The Delphi method is appropriate as a process for generating a consensus among experts in the field of digital imaging for determining curriculum content germane to the printing industry. Eliciting responses from knowledgeable experts will produce agreement on specific competencies (Walker, 1992). This technique as a research tool has been used in many instances when gathering information about the use of new technology (Martino, 1972; Walker, 1992). Originally established by the Rand Corporation as a tool for technical forecasting, this process enables researchers to make sound decisions concerning inquiry about specific issues (Martino, 1972). As a means for determining curricular content, the Delphi technique is effective in obtaining from a series of iterations, opinions from a group of experts that is non-biased as a solution to a defined problem.

SUMMARY

Changes to technology curriculums are "an ongoing, long-term process" (Lauda & McCrory, 1986, p. 41). The Delphi does alleviate the determination of the what, how, when and why of the curriculum, as a methodology for the identification of educational goals and objectives. Using the Delphi process to identify competencies clarifies for the curriculum developer what must be done as decisions and justification of how people, content, materials, time, space, and activities are considered in the design of a technology oriented curriculum (Lauda & McCrory, 1986, p.37). For the Technology Graphic Arts and Imaging Technology curricula, the identification of digital imaging competencies should be the first step in the design of a functional and relevant curriculum.

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An Analysis of Tests Authored by Technology Education Teachers

W. J. Haynie, III, Ph.D.

Department of Mathematics, Technology, and Science Education

North Carolina State University

(Refereed Article)

An Analysis of Tests Authored by Technology Education Teachers

W. J. Haynie, III

Associate Professor & Coordinator

Technology Education Program

Department of Mathematics, Science, and Technology Education

North Carolina State University

P.O. Box 7801

Raleigh, NC 27695-7801

Phone (919) 515-1748

FAX (919) 515-6892

Running head: Analysis of Tests

Abstract

This research evaluated classroom tests authored by technology teachers to determine the types of items used, how teachers were prepared to dvelop tests, how tests matched the stated objectives, and the number and types of errors in the items written by teachers. Volunteers participated in the study. The teachers ranged in experience from 2 to 25 years. About half of the teachers had Master's degrees. Some of the findings were: The teachers varied in their ability to author clearly worded items, in the types of items they selected for use, and in other factors examined concerning the types of errors they made. The character of tyhe tests varied also. Teachers appeared to have greatest difficulty authoring effective multiple-choice items. The tests were predominantly testing at the lowest levels of the cognitive domain. Word processing results in development of better tests than other methods.

An Analysis of Tests Authored by Technology Education Teachers

The acheivement of students in the secondary schools is assessed most often with teacher-made tests. In technology education classes, teachers frequently author their own tests. The effectiveness of the teacher-made tests used in technology education courses depends upon many factors. The quality of each individual item is of great importance and how they work together to reflect the objectives tested is also of concern. This study sought to determine the quality of teacher-authored tests and the individual items within them.

Background

Students take numerous standardized tests and teacher-made classroom tests in secondary school (Bott, 1995; Haynie, 1983, 1990, 1991, 1992, 1994, in press; Hoepfl, 1994; Herman & Dorr-Bremme, 1982; Mehrens & Lehmann, 1987; Newman & Stallings, 1982). Mehrens (1987) estimated that students may take up to 1,000 teacher-constructed tests before leaving secondary school. Despite this frequent dependance upon teacher-made tests for evaluation, Stiggins, Conklin, and Bridgeford (1986) point out that "nearly all major studies of testing in the schools have focused on the role of standardized tests" (p. 5).

A few studies have been completed concerning teacher-constructed tests and their use, but they have had findings which were not promising concerning teachers' understanding of measurement (Fleming & Chambers, 1983; Gullickson & Ellwein, 1985; Haynie, 1992; Mehrens & Lehmann, 1987; Stiggins & Bridgeford, 1985). Researchers have found that teachers lack sufficient training in test development, fail to analyze items and tests, do not establish reliability or validity, do not use a test blueprint, often weight all content equally, rarely test above the basic knowledge level, and frequently use tests with grammatical and spelling errors (Burdin, 1982; Carter, 1984; Gullickson, 1982; Gullickson & Ellwein, 1985; Haynie, 1992; Hills, 1991). Technically their tests are simplistic and depend heavily upon short answer, true-false, and other easily prepared items. When multiple-choice items are used, they often have serious flaws--especially in the distractors (Haynie, 1990, 1992; Mehrens & Lehmann, 1984, 1987; Newman & Stallings, 1982).

Even though teacher-made tests are often seriously flawed, Mehrens and Lehmann (1987) point out their importance by asserting that: "Classroom measurement devices, because they can be tailored to fit a teacher's particular instructional objectives, are essential if we wish to provide for optimal teaching and learning" (p. 36).

In 1992, Haynie reported on a post hoc analysis of test items authored by technology education teachers. The items were prepared according to guidelines and a test blueprint developed for the North Carolina State Department of Public Instruction, Vocational Education Division to use in a state-wide assessment program. The items were entered into a computerized test item bank. Only multiple-choice items were used and very ridgid specifications were followed in their development and editing. There were some flaws in over 80% of the items the teachers authored. Not all teachers had taken either undergraduate or graduate courses in testing and measurement, but those who did prepared better items. Teachers with graduate degrees developed superior items. Teachers did write items with good face validity, but their items were largely only testing in the lowest levels of knowledge: Bloom's Taxonomy Level 1 = 56% and Level 2 = 38%, only 5.5% tested at Level 3 or above. That study examined discrete items only, it did not in any way evaluate the quality of entire tests authored by teachers for use in their normal teaching setting. It did not determine the types of items typically selected for use, how well teachers reflected the content taught in their testing, nor how the items were actually prepared. Research is lacking on the quality of the intact tests written by technology education teachers for use in their classes.

Purpose

The purpose of this investigation was to study the quality of technology education tests authored by teachers. Face validity, clarity, types of items used, toxonometric level, and rates of spelling and punctuation errors were some of the determinants of quality assessed. Additionally, data was collected concerning teachers' experience levels, highest degree held, and sources of training in test construction. The following research questions were addressed in this study:

1. What types of items do technology teachers include in the tests which they author?
2. What types of errors are common in test items authored by technology education teachers?
3. Do the error rate or types of errors in teacher constructed test items vary with factors such as: years of teaching experience, completion of undergraduate and graduate test and measurement courses, method of test production (word processing, typing, etc.), or type of item?
4. Do technology teachers have a firm understanding of how to match test items to curriculum content and to taxonometric level so as to develop tests which adequately reflect the content taught?

Methodology

Sample

At an annual meeting of the North Carolina Technology Education Association during the NC Vocational Summer Conference hosted by the State Department of Education, the researcher addressed a general session and requested volunteers to participate in the study. Twenty-one teachers volunteered to participate. Each was given a survey form and a cover letter with instructions. The instructions asked participants to complete the demographic survey and to submit intact tests of at least 25 items for assessment. Along with the tests, participants were requested to submit the objectives the tests evaluated; to code each item indicating which objective it covered; and to indicate whether they originally authored the items or copied them from a commercial source, textbook, or the state test item bank. Teachers were asked to return the information within two weeks.

Since participation required much more work than a typical survey, it was expected that there would be a low response rate. Of the 21 teachers who volunteered and initially obtained the instructions and survey, 15 (71%) returned some information. Unfortunately, 4 of those who responded did not return complete entries and could therefore not be used. Since no identifying information was included on any of the materials, to insure total annonymity, there was no possibility for followup procedures to obtain more useable data. The final usable return rate was 52%. Despite the low number of complete packets received, there was a good balance of types of entries and a total of 586 individual test items to assess. The teachers were all active in the North Carolina Technology Education Association and claimed to support the transition to the new curriculum. Table 1 displays demographic data concerning the authors.

Data Entry

All returned packets which were found to be fully complete were assigned random author numbers. Each item of evidence in a given packet was marked with this unique author number to insure that nothing was misplaced or confused with other packets. Then, the tests were carefully proofread and all spelling and punctuation errors were clearly marked. Next, each item was read for content and compared with the objectives which the author had reported that it assessed.

A coding sheet was completed for each author's tests. The coding sheet summarized the demographic information and then recorded the findings about each item on the author's test. Scores for the ratings were all numbers with 0 indicating that there was no problem or a good item and higher numbers indicating various problems. All of the ratings were summed for each item to determine a total Quality score. An item with a spelling error, one punctuation error, an invalid distractor, and some problem in clarity would receive a total Quality score of 4--this would be a very poor item. A good item would have a Quality score of 0.

After all of the ratings were completed, the data were submitted to analysis in Statistical Analysis System (SAS) software on a microcomputer. The General Linear Models (GLM) procedure was used for F testing and the LSD procedure was used when t-tests were appropriate.

Findings

Six of the 11 teachers had a bacheor's degree and the remaining five had completed a master's degree (Table 1). The experience of the teachers ranged from 2 to 25 years with an average of 11.6 years. To make convenient comparisons by experience level, teachers with fewer than 8 years of experience were grouped and compared with teachers who had more than 8 years of experience--since no teachers had exactly 8 years of experience and this resulted in nearly equal group sizes (6 teachers--279 items, and 5 teachers--307 items respectively), it was felt that these were appropriate groupings for the available data. Six of the teachers had taken a course in measurement and evaluation as undergraduate students and 4 had taken such a course as graduate students. Three of the teachers had taken no courses of this type at all and two had taken both undergraduate and graduate level courses on measurement.

Spelling Errors (SE)

The frequency and percentage of scores for the 586 items on the 7 ratings of quality factors, and the mean scores of each factor, are shown in Table 2. The mean scores for each teacher on the factors is shown in Table 1. An item's SE rating indicates how many words were misspelled in the item. There were 560 items with no spelling errors (95.6%), and 26 items which had one or more spelling errors. Only 1 item had more than one spelling error. All spelling errors are detrimental to good teaching and testing, so this could potentially be a problem area, however the literature review shows that this problem is common to other disciplines in education and not unique to technology education. In 1992, Haynie reported that 9.9% of the items written by a similar group of teachers contained one or more spelling errors. One potential source of improvement in spelling is the increased use of word processing software--six of the teachers in this study used word processors to develop their entire tests, one used a word processor for two-thirds of his/her items, and another teacher photocopied all of his/her items from a commercial textbook (which had been professionally edited). In the 1992 study, only a few of the teachers had used word processing equipment to develop their items. The spell checking functions of word processing software appears to have been very helpful in improving the overall quality of the items evaluated here.

The authors were compared on the spelling errors factor and were found to differ significantly: $F(10, 575) = 2.86$, $p<.0017$. Followup analysis with the LSD procedure showed that 5 authors had significantly fewer spelling errors and 1 author had more than the average number of errors in spelling (Table 3). The author with the highest rate of spelling errors also had many other defects and was rated significantly higher (worse) in the overall Quality (Q) rating (author 9).

The means on the Spelling Errors factor of teachers in the two experience level groupings were compared and there was no significant finding with an $F(1, 584) = 2.48$, $p=.1156$. Likewise neither undergraduate nor graduate level measurement courses were found to be important factors leading to spelling accuracy among the teachers, but the method of actually producing the tests was important. A significant finding of $F(5, 580) = 3.34$, $p=.0056$ was achieved when the six methods of production were compared in regard to spelling errors. Word processing did help teachers spell better in the items they authored.

Punctuation Errors (PE)

The mean score in the Punctuation Errors category (the PE rating was the total number of punctuation errors in an item) was 0.097 with a range of 0 to 3 (Table 2). There were 536 items (91.5%) with no punctuation errors and an additional 44 of the 586 items had only one punctuation error. Only 1.1% of the items had more than one punctuation error. The most frequent punctuation errors were ommission of punctuation at the end of the stem of a multiple-choice item or use of the wrong punctuation there. Frequently, non interrogatory statements were ended with question marks or stems which should have ended with a colon were left with no punctuation. This score may be inflated spuriously by those unique errors which may not have been made in normal prose writing by the same teachers, but teachers should be careful that anything they give to students meets the highest possible standards of precision and technical accuracy.

Among the 11 authors, a significant difference was found in the PE category: $\underline{F}(10, 575) = 4.37$, $\underline{p} < .0001$. Table 3 shows that three authors had significantly more than average numbers of punctuation errors. One of the teachers with excessive punctuation errors rated significantly better than his/her peers in 2 other categories (including validity--author 10). Three authors had significantly low numbers of punctuation errors and all of these had also rated superior in spelling accuracy. Neither undergraduate nor graduate courses appeared to influence teachers' accuracy in punctuation, but both experience level and method of test production did have effect. The more experienced teachers had better punctuation ($\underline{F}(1, 584) = 9.97$, $\underline{p}=.0017$) and those teachers who manually typed or hand wrote their tests had more punctuation errors ($\underline{F}(5, 580) = 2.69$, $\underline{p}=.0205$).

Distractors (D)

Errors in the distractors of multiple-choice items which could not be classified as spelling or punctuation errors were summed in the Distractors (D) rating. There were a total of 119 multiple-choice items (20% of the entire data set) and there were 84 non-spelling and non-punctuation errors in the distractors. Fifty-two of the multiple-choice items had one D error, 10 had 2 D errors, and four had 3 D errors; so, 66 of these items had at least one flawed distractor (55%). Frequently these errors either eliminated certain distractors or targeted the correct answer due to incompatibility between the stem and the alternatives because of lack of agreement in: singular-plural, introductory article, tense, or even gender. Multiple-choice items are more difficult to write than most other types. In fact, these distractor errors account for 31% of all of the errors of all types in the tests examined!

Overall, it appears that teacher-developed multiple-choice items are of questionable value. All of the teachers who had large sections of multiple-choice items on their tests rated worse in the overall quality of their tests, and a large portion of their problems involved their multiple-choice items. Though multiple-choice items are considered the best for many uses, these have so many flaws that they detract from the overall quality of the tests which contain them.

Usability (U)

The Usability (U) rating totalled all errors and defects not included in the SE, PE, and D ratings but which are primarily mechanical in nature (rather than validity or clarity problems). An example of an error which would not be counted in the first three ratings but which would be included here is an item which begins with a blank. Though this is poor grammer, it would not have been counted as a punctuation error, but the item's stem should have been rewritten to give students more information before they were cued to search for the answer. Such an item would have a U rating of 1. Only 9 (1.5%) of the 586 items were found to have an error classified as a usability (U) error. Other than adding them as a part of the total Quality (Q) rating later, there was no practical reason for further analysis of the U ratings.

Validity (V)

Items were carefully read and compared to the objectives they were intended to test, as submitted by the teachers, to assign a Validity (V) rating. A rating of 0 indicated the item clearly possessed face validity. An item which was obviously off the subject was rated 2 and items which tested information immediately adjacent to the intended information were rated 1 to indicate that their face validity was questionable at best. Most of the items

(567, 96.8%) were judged to have good face validity (V = 0). Only 15 of the 586 items (2.6%) were deemed to be totally invalid (Table 2). Most of the invalid items were actually jokes which the teachers had interspersed into the test to break students' tension. This practice might have some merits in some situations, but would generally be considered a distraction and would likely reduce the validity and reliability of the tests.

The authors differed significantly in how valid their items appeared to be: $F(10, 575) = 3.35$, $p<.0003$. It is noteworthy that the Validity rating did not neccessarily correspond to others in the study. One of the authors (number 9) who rated significantly better in terms of validity was one of the worst rated authors in other categories, including overall Quality.

The following findings related to the demographic variables were also attained: More experienced teachers wrote more valid items, $F(1, 584) = 9.13$, $p<.0026$; teachers who had experienced undergraduate test and measurement courses submitted more valid items, $F(1, 584) = 4.08$, $p<.044$; and graduate courses also helped teachers write more valid items, $F(1, 584) = 8.88$, $p<.0030$.

Clarity (C)

Clarity (C) was a rating indicating to what extent the item should be clearly understandable to students. This was a subjective rating by the researcher. If, in the researcher's judgement, the item should have been clear enough to lead knowledgeable students to the correct response, regardless of other types of errors (SE, PE, D, U, or V ratings), then that item was rated 0 in the C category. Items which were confusing to read with no clear purpose set forth were rated 2. Items which, in the researcher's judgement, would likely work but which had some element of confusion were rated 1. Table 2 shows that most of the items (458, 78.2%) were judged to be reasonably clear in intention. Only 28 (4.8%) of the 586 items submitted were deemed to be so confusing as to deserve a rating of 2. However, over 21% of the items these teachers developed had at least some element of basic confusion.

The finding of $F(10, 575) = 4.41$, $p<.0001$ documents that teachers did vary in their ability to write clear items according to this rating. Of the demographic factors investigated, only the teachers' experience level was shown to be significantly related to the ability to prepare clearly worded item stems: $F(1, 584) = 5.13$, $p<.0239$, teachers with more than eight years of experience developed superior items in terms of clarity.

The clarity of differing types of items varied significantly: $F(8, 577) = 2.97$, $p<.0029$. Matching items were the worst in terms of clarity, but this may be an inflated finding because any matching item in which the longer portion of the matched pair was in the "answer" column instead of the "stem" column was given a 1 on the Clarity (C) rating. Some teachers who used many multiple-choice items (number 1, 42%, and number 4, 24%) had particularly unclear items, but one teacher who used 48% multiple-choice items developed very clear items.

Quality (Q)

The overall Quality of the test items was summarized in the Q rating. The Q rating was found by summing all of the other ratings. The Q ratings of the items are shown in Table 2. They range from 0 (an item judged to need no editing of any sort and believed to operate exactly as the submitting author had intended) to a high value of 5. Over 63% of the items rated 0 in this category. Of the 586 items, 115 had a rating of 1 (19.6%) which indicated one problem of any sort (a single spelling error, a punctuation error, a ruined distractor, or some other problem)--most of these items should probably still have been useful in the classroom. Thus, it is likely that 80% or more of the items were usable and would have helped the teacher who wrote them assess student achievement.

A finding of $F(10, 575) = 8.46$, $p<.0001$, shows that the teachers differed significantly in the Q ratings of their items (see Table 3). All of the teachers who differed significantly in the Q rating had also been found to differ in several other categories. Experienced teachers prepared items with better overall quality than inexperienced teachers: $F(1, 584) = 39.54$, $p<.0001$. Undergraduate test and measurement courses did not appear to help teachers develop higher quality items, $F(1, 584) = 0.05$, $p<.8225$, but teachers who had taken graduate courses did submit items with better overall Quality (Q) ratings, $F(1, 584) = 9.31$, $p<.0024$.

There was a significant finding of $F(8, 577) = 12.61$, $p<.0001$ indicating that the overall Quality (Q) of the test items varied with the types of items used. Of the items which were used frequently, multiple-choice items had the worst overall quality. It should be noted that discussion (essay) items actually had a poorer score, but they only represented 1% of the entire data set, so one very badly written essay item likely had a large effect on the overall Quality mean for this type of item. The best items were those classified as "practical" items. These were items which asked students to complete portions of a CAD (Computer Aided Drafting) assignment, complete portions of a computerized spreadsheet, or actually perform some task. One teacher who had a very good overall test (number 2) used 34% of such practical items, but they only represented 4% of the total data and thus were probably also insignificant.

Of those types of items which were most frequently used the best were short answer items, and they were also the most often used (40%). The rank order of the four most commonly used types of items in terms of overall Quality from best to worst was: short answer, matching, true-false, and multiple choice. Items involving a "picture", such as the traditional drawing of a machine with a request for students to identify the parts, were used by two teachers (4% of the data), and 3% of the items could not be accurately described by any of the eight named categories used to analyze the data and were entered as "other".

Taxonomy (TX Level)

The Taxonomy (TX) rating indicates the taxonometric level of the cognitive domain for each item. Three levels were used. The codes used were derived from the first three levels of Bloom's Taxonomy: 1 indicated simple knowledge, 2 indicated comprehension, and 3 indicated application or higher levels of learning. It was felt that there would be few items which tested above the application level.

Of the 586 items submitted, 487 (83.1%) operated at level 1 (knowledge), 64 (10.9%) operated at level 2 (comprehension), and only 35 (6.0%) operated at level 3 (application or above). Authors 2 and 5 were the only ones who ventured to wirte items to test at the third level or above (36% and 10% respectively). Two authors did not test above level one at all (teachers 8 & 9). Only five teachers tested at level 2 or above with at least 20% of their items. In general, these tests operated primarily at the lowest level of the cognitive domain.

Other Characteristics and Findings

There were other unexpected and unusual findings, many of which concerned the whole nature of the teacher's test rather than a specific item or section. Many of the teachers did not test evenly across the objectives they submitted. In fact, 6 teachers did not test some of their objectives at all, 2 others had very unbalanced tests (one had 3 objectives tested at the rates of 1 = 64%, 2 = 10 %, and 3 = 18%; the other one had two objectives: 1 = 94%, 2 = 6%), and 2 others were only testing one objective to begin with. Only one teacher, number 6, truly had a resonably well balanced test. It was obvious that most of these teachers had not used any sort of test blueprint to develop their instruments. The validity of each item was examined and reported earlier, but this finding reveals that (even if the individual items were reasonably valid) the test instruments as a whole must have been quite low in overall validity. Much of this may be due to convenience--it is easier to make up a section of matching items on simple terminology than it is to develop and score several multiple-choice items and a few essay items. Once the decision to use matching items is made, they will all likely be similar, test at the lowest level of knowledge, and (if they are to be usefully parallel) test the same learning objective (i.e. knowledge of vocabulary).

Two teachers used matching sections which were not made up of parallel items. Some of their stems were names of tools, others were steps in a process, others were terms from technology or labor relations (mediation and fixture were in the same list), and still others were names of key inventors--all of these were in the same section. A student who actually knew very little of the information covered should still have been able to guess a large number of correct answers by process of elimination.

Two teachers had jokes imbedded within their tests which appeared to be serious items until they were read. One more teacher had two cartoons printed on the test copies which were obviously not items on the test. Neither of these practices are encouraged, but the cartoons at least did not distract attention in the same way as fake items would.

One teacher had students sketch a device from memory and lable the parts. One teacher had a set of matching items which began on one page and then continued to the next page (both columns) so that a student must continually turn back and forth from page to page to respond. This same teacher was one of the three who had matching sections with the longer part in the answer column and the shorter part in the stem column. Students should read the longest portion first and then search the answer column quickly (because it has shorter entries) to find the match. Presenting the items backwards in this way wastes much student time and unduly frustrates slow readers who may truly know the material well. Two teachers used picture identification matching sections. One of these had separate, discrete pictures of devices and tools to identify, the other asked students to match the names of parts of one machine to a drawing of it with letters as lables. One teacher had a section in which students were to order the steps of a process--the steps were presented in the item. Only one teacher had "extra credit" items on the test, and the items were both mathematical problems which likely did go a little beyond the level of the objectives stated for the test, though they were on related material. None of the tests evidenced poor quality in reproduction (most were reproduced via xerography, though one teacher used a spirit duplicator) and even the sections of some tests which were hand written were clearly readable and neatly prepared. Only one teacher had used a pre-prepared separate answer sheet and one other had all answers placed on an answer sheet prepared by the students on notebook paper.

Discussion

Teachers differed significantly in their ability to prepare good test items. Undergraduate and graduate courses in testing and measurement, though they appear to be helpful in many ways, are not taken by all teachers. Undergraduate courses appear to have helped teachers prepare more valid items, but did not improve the quality of their items on any other ratings including overall Quality (Q). By contrast, teachers who had taken graduate measurement and evaluation courses developed items with better multiple-choice distractors, better validity, and better overall Quality than those who had not experienced such courses.

Teachers with more than 8 years of experience developed items with better overall quality (Q rating) than those who had less experience. The more experienced teachers significantly outperformed their less experienced peers on 5 of the quality factors studied: punctuation, distractors, validity, clarity, and overall quality.

One thing that appears to have improved the overall quality of test items written by technology teachers, and the tests they construct, is the increased use of word processing. The advice here is to encourage more teachers to use word processing to develop tests and to recommend that faculty teaching measurement and evaluation and methodology courses stress the improvement in test quality which word processing can support.

One criticism which researchers have frequently leveled at teacher-made tests is that they too often depend upon easily written and simplistic short answer items. This study found that 40% of the items submitted were short answer items, but it also found that they were the best items in terms of the 7 ratings of quality examined here. When teachers attempted to develop multiple-choice items, the preferred ones among testing experts, they had far more difficulty than when they kept things simple. There were 84 errors in the distractors of the 119 multiple-choice items in this study (70.6%). It is true that it is difficult to develop effective items to test at higher levels of the cognitive domain, that teachers often use simplistic items and rarely do test above the knowledge level, and that multiple-choice items are often more suitable than other types for testing at the higher levels, but teachers who cannot write effective multiple-choice items should not be encouraged to use them in an effort to evaluate at a higher level. It would be better for a classroom teacher to develop a good test which is clear and unambiguous but limited to lower level knowledge than it would be for them to develop a confusing test with low validity and reliability seeking to measure higher level learning via poorly prepared multiple-choice items. Neither of these approaches would give the teacher a dependable measure of students' attainment in higher level learning, but at least the simpler test would be valid for assessing low level knowledge. The complex but deficient test form would not be useful in any way. The advice here is that teachers should not try to write multiple-choice items unless they are well educated to do so. Further, if they elect to use multiple-choice items developed by some other source (commercial textbook or teacher's manual, commercial or state department generated curriculum guide, or other), they must be knowledgeable enough to evaluate and revise each item to insure that it truly fits their situation and is a well prepared item. Lastly, teachers should be taught somewhere in their undergraduate education programs how to develop and analyze good multiple-choice items if we are to expect them to evaluate their students at the upper levels of the cognitive domain. This knowledge should be built upon further in graduate studies.

The teachers who submitted tests for scrutiny in this study had developed tests which were high in face validity. One young teacher, with only 2 years of experience, had evidently taken little responsibility for accurate testing of students and elected to use a collection of items "lifted" from a commercial textbook source. On the surface, this might seem to be a good idea to an inexperienced teacher, and if the test items were truly well developed ones it might actually be acceptable. However, the test submitted here was very poor in many regards. Many items had questionable validity, were unclear, or had other problems.

Recommendations for Further Research

Additional research is needed to assess the quality of intact teacher-made tests and study the problems which could not be addressed by this investigation. This study examined many items but only a few teachers (11). Investigations should be conducted which study the test items and intact tests developed by larger groups of technology education teachers. Since most testing experts agree that multiple-choice items are especially good for testing a broad range of information and at various levels of the cognitive domain, research should be conducted to determine how to best educate teachers on how to develop useful multiple-choice items and when they are appropriate to use. Considerable research has been conducted on standardized tests, but much more research is needed on all aspects of teacher-made tests and their use.

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Table 1

Profile of Authors' Demographic Factors

Author	Number of Items	Years of Teaching Experience	Highest Degree	Undergraduate Test & Measure Courses	Graduate Test & Measure Courses	Method of Production
1	50	7	B.S.	1	0	T & W
2	76	25	B.S.	1	0	W & WP
3	34	2	B.S.	0	0	WP
4	50	2	B.S.	0	0	C
5	77	22	M.Ed.	1	1	WP
6	50	10	M.S.	0	1	WP
7	36	22	M.A.	0	1	WP
8	68	24	M.S.	1	1	WP
9	70	6	M.S.	1	0	T
10	43	5	B.S.	0	0	WP
11	32	3	B.S.	1	0	W

Key -- Methods of Production:

T = Typewriter

W = Handwritten

WP = Word Processor

C = Copied from commercial or public source

Table 2

Ratings of Test Item Quality

Rating Category	Score	Frequency of Items With Each Score	% of Items/ Score	Mean Item Score
Spelling Errors (SE)	0	560	95.6	
	1	25	4.3	
	2	1	0.2	
SE Totals	---	586	100%	0.046
Punctuation Errors (PE)	0	536	91.5	
	1	44	7.5	
	2	5	0.9	
	3	1	0.2	
PE Totals	---	586	100%	0.097
Distractors (D)	0	520	88.7	
	1	52	8.9	
	2	10	1.7	
	3	4	0.7	
D Totals	---	586	100%	0.143
Usability (U)	0	577	98.5	
	1	9	1.5	
U Totals	---	586	100%	0.015

Table 2 (Continued)

Validity (V)		0	567	96.8	
		1	4	0.7	
		2	15	2.6	
	V Totals	---	586	100%	0.058
Clarity (C)		0	458	78.2	
		1	100	17.1	
		2	28	4.8	
	C Totals	---	586	100%	0.266
Quality (Q)		0	371	63.3	
		1	115	19.6	
		2	62	10.6	
		3	27	4.6	
		4	8	1.4	
		5	3	0.5	
	Q Totals	---	586	100%	0.626

Note. There were 586 items.

Table 3

Means of each Author on the Rating Categories

	Per Item Means (Ratings)							Taxonomy Levels %			Types of Items %						
Author	SE	PE	D	U	V	C	Q	1	2	3	SA	MC	TF	MT	Prac	Pic	Other
1	0.02	0.08	0.36	0.06	0.20	0.40	1.12	98%	2%	0	30%	42%	0	28%	0	0	0
				**	**	**	**										
2	0.01	0.01	0	0	0.05	0.05	0.13	47%	17%	36%	66%	0	0	0	34%	0	0
	*	*				*	*										
3	0	0	0.03	0	0.12	0.06	0.21	65%	35%	0	18%	0	0	35%	0	0	47
	*	*				*											
4	0	0.04	0.08	0	0.22	0.46	0.80	94%	6%	0	0	24%	28%	48%	0	0	0
	*	*			**	**											
5	0.09	0.08	0.13	0.03	0	0.12	0.44	68%	22%	10%	43%	48%	0	0	6%	0	3
						*											
6	0.04	0.06	0.06	0.04	0.04	0.34	0.58	98%	2%	0	96%	2%	2%	0	0	0	0
7	0	0.06	0	0	0	0.22	0.28	97%	3%	0	6%	0	0	94%	0	0	0
	*				*		*										

Table 3 (Continued)

Means of each Author on the Rating Categories

	Per Item Means (Ratings)							Taxonomy Levels %			Types of Items %						
Author	SE	PE	D	U	V	C	Q	1	2	3	SA	MC	TF	MT	Prac	Pic	Other
8	0 *	0.07	0	0.03	0 *	0.43 **	0.53	100%	0	0	65%	0	1%	0	0	22%	12
9	0.13 **	0.19 **	0.43	0	0 *	0.37	1.10 **	100%	0	0	21%	36%	29%	14%	0	0	0
10	0.09	0.35 **	0.42	0	0.07	0.23	1.16 **	79%	21%	0	0	53%	19%	28%	0	0	0
11	0.09	0.19 **	0	0	0 *	0.28	0.56	78%	22%	0	59%	0	22%	13%	0	3%	3
Grand Means	0.046	0.097	0.143	0.015	0.058	0.266	0.626	83%	10%	6%	40%	20%	9%	19%	4%	4%	4%

Note. There were 586 items.

* Significantly low (better), $p<.05$.

** Significantly high (worse), $p<.05$.