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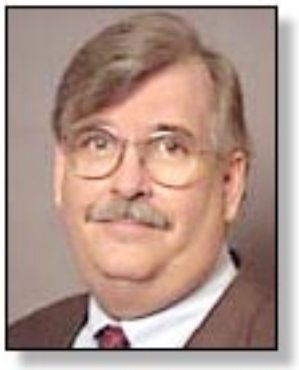

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Introduction

Computer technology related programs in the field of industrial technology represent a rapidly emerging area of study. In the *NAIT Demographics Study – 1997* (Kulatunga, Shaw, & Nelson, 1999), only two Computer Technology oriented NAIT programs were identified nationwide; one in Computer Technology and one in Telecommunications. The following year, based on a review of the 1998 NAIT Directory, Zargari and Coddington (1999) identified six such programs: five in computer technology and one in telecommunications. Four years later, a review of the NAIT Program Directory (2003) for baccalaureate level Industrial Technology related computer technology programs identified 16 NAIT accredited programs. Thus, the growth has been dramatic.

Rapidly emerging programs must be continuously assessed and monitored to make certain that they are academically appropriate, differentiated from other computer-related programs, and are meeting the needs and expectations of key stakeholders. Benchmarking provides a means to achieving those goals (Alstete, 1995). Considerable discussion has occurred in recent years in the business and computer science forums about the importance of identifying curricula for computer technology-related baccalaureate programs to prepare students with the necessary skills in current technology and practice for entry jobs in the present as well as the abilities to learn new technological skills throughout their careers (Lightfoot, 1999)

Purpose of the Study

The purpose of this study was to answer the following questions:

- What is the current status of computer technology related degree options contained in or affiliated with Industrial Technology baccalaureate degree programs?
- What trends can be identified in the evolution of computer technology related programs contained in or affiliated with Industrial Technology baccalaureate degree programs?

Methodology

Population/Sample. Sixteen NAIT accredited computer technology related programs were identified as the basis of this study. Requests for nominations of additional similar non-NAIT accredited programs with connections to Industrial Technology produced six additional program names. Thus, a total population of 22 computer technology related programs with Industrial Technology affiliation or roots was identified. Faculty from 14 NAIT accredited and four unaccredited programs agreed to participate in the structured interviews that were used to collect data for the study. Faculty from two NAIT accredited and two unaccredited programs declined to participate, generally indicating that they were either too busy or had limited access to the requested information.

Design of the Study. The design for this study was based on the model of Functional Benchmarking which involves broadly comparing competitors with similar functions or programs across similar markets (Alstete, 1995). Benchmarking, as used in this study, is intended to identify and provide key

understandings of the performance of programs as the basis for informed decision-making and strategic planning for the future of the program (Copa & Ammentorp, 1998). This was a multi-case study evaluative research design involving 18 programs nationwide. Even though the number of cases is relatively large for a case study, we chose to examine as many cases as possible in order to obtain a more comprehensive view of these programs nationwide. This allowed the achievement of greater comparative understanding of the state of this field emerging from under the umbrella of industrial technology (Johnson & Christensen, 2000). Qualitative and quantitative data collection methods were employed to provide a snapshot of the current state of the development of these programs. Using mixed methodologies for researching multiple programs dispersed across wide geographic areas provides a mechanism for better understanding and reporting similarities and differences across sites (Worthen, Sanders & Fitzpatrick, 1997).

A structured interview format was used to allow comparison across programs while facilitating clarification and probing as needed (Worthen, Sanders & Fitzpatrick, 1997). In evaluative research, the term triangulation is used to describe the process of examining results from multiple sources measuring related constructs and methods to search for similar findings. When information from diverse sources converges, greater confidence in findings is possible (Worthen, Sanders, & Fitzpatrick, 1997). Contact persons were identified from the NAIT website and directory. Prior to the actual interviews, potential participants were contacted by telephone to (a) explain the intent of the study, (b) provide information about the level of participation requested, and (c) establish a future date and time for an interviewer to call back to conduct the interview. After informing each participant of their risks and rights, structured telephone interviews of approximately one half hour duration were conducted. In addition to the interviews, program and institutional catalogs were also analyzed and course requirements were reviewed and summarized.

Instrumentation. Zargari and Hayes (1999) conducted a study of the perceptions of 220 Industrial Technology alumni designed to identify aspects of Industrial Technology programs. The results of their study indicated that three types of courses were rated highest. In descending order, these were: (a) technical content courses, (b) courses with hands-on, laboratory experiences, and (c) internship or on-site projects. Inspired by these findings, an analysis of course taking patterns as well as discussions of program emphasis, internships, certifications, and placements were included in this study. A panel of industry experts working in computer technology related fields reviewed the first draft of the instrument to evaluate its content validity as well as readability. Changes were made to both content and phrasing based on their suggestions.

Data Analysis. When analyzing mixed quantitative and qualitative data, researchers should search for patterns and themes that provide particular relevance to the phenomena being studied. This approach was utilized and supplemented by triangulation of data to synthesize qualitative and quantitative findings. Analysis of qualitative data as well as synthesis of triangulated data was accomplished through an extensive search for patterns and themes across the data (Johnson & Christensen, 2000; Lincoln & Guba, 1985; Patton, 1980; Seidman, 1991; Worthen, Sanders, & Fitzpatrick, 1997).

To analyze patterns of program course requirements, university catalogs and/or student advising sheets posted on the web were reviewed to identify program specific content. When required courses were encountered repeatedly, they were clustered and identified using a set of abbreviated course descriptors. These courses were then thematically clustered (e.g., microcomputers, networking, mathematics, communication skills, management and business, and technical content).

Findings

Program Demographics. Enrollments at the 18 programs examined ranged from 4 to 600 students with a median enrollment of 100. Sixteen of the 18 faculty responding projected either steady or increasing program enrollments in the future.

Program Emphases. One of the most important issues addressed focused on the curricular models and areas of program emphasis that have emerged in the computer technology related areas. To obtain this information, respondents were asked to rate a series of program emphasis categories on a 1 to 10 scale with 10 representing the strongest emphasis. The categories included: electronics, data management (acquisition, storage, retrieval, archival), computer hardware (planning & maintenance), networking administration, utilities & diagnosis software (i.e., sniffer, ghost, system maintenance & diagnosis), Operating systems, software applications (i.e., Office applications, CAD, etc.), Programming (i.e., Visual Basic, C++, Java, etc.), telecommunications, web-development, and general management (project management, etc.).

Through the use of a Principal Component factor analysis, analysis of correlations, and visual comparisons conducted by the research team, some clustering of categories and program emphasis areas appears to be emerging in industrial technology associated programs. The three areas of emphasis include: (a) hardware/electronics, (b) telecommunications and systems network management, and (c) programming and data systems management. It is important to note that the three emphasis areas tend to be represented in varying degrees across the universities surveyed. For example, some programs put more emphasis on the hardware/electronics than on telecommunication or programming, while other placed more emphasis on telecommunications or programming. Each of these emphasis areas will now be discussed in more detail.

Faculty from many programs reported heavy emphasis on hardware/electronics. This observation is not surprising, since many of the computing related programs grew out of electronics technology or electronics engineering technology programs of study. With the emergence of computing technology, digital electronics, and other computer-intensive technologies, this emphasis represents a natural advancement and evolution of the field. Computer-based electronic devices are embedded throughout the entire range of program areas typically included in industrial technology.

The second emphasis area that emerged from the analysis concentrated on telecommunications and systems network management. Consistent with the electronics/hardware emphasis, this systems management emphasis represents a practical and applied area of computing, where the focus is on configuring, maintaining, diagnosing, and managing network computing systems. Throughout the interviews, when asked how industrial technology-oriented programs differ from other computing related programs on their campuses, respondents consistently indicated that their programs were much more applied than computer science, business information systems, or computer engineering programs. By contrast, the goal of the programs included in this study was providing students with a solid working knowledge of how networked systems function. Another goal identified was to provide students with the skills needed to manage those systems.

The third emphasis area focused on programming and data systems management, including some involvement with programming and database management. As with the systems management emphasis, the respondents indicated that their approach was more applied than in computer science, where programming and databases were addressed at a much more theoretical level. It should be noted that this cluster area is closely related to the systems management emphasis, since a basic understanding of languages such as JAVA, Visual Basic, and C++ are necessary for maintaining and managing networked systems. The same is true for a basic, working knowledge of database structures. While these findings are preliminary, it is apparent that areas of emphasis are emerging in NAIT oriented computer technology related programs. These areas of emphasis are generally consistent with the applied and integrated nature and culture of the industrial technology field.

Required Course Taking Patterns. Required courses encountered multiple times were clustered and identified using abbreviated descriptors. Tables 1, 2, & 3 present information indicating what percentage of programs listed a course category as required. The tables also contain the mean and median number of hours of coursework per subject matter as well as the range in number of hours required for that particular subject matter. Courses were clustered by categories such as mathematics and professional communication skills, management and business, and technical content. Table 1 indicates that the required hours for mathematics courses ranged from four to ten credit hours. Twenty eight percent (5) of programs required at least one course in trigonometry and 44% (8) of programs required one or more courses in calculus. Six of the programs that require calculus were NAIT accredited and one planned to seek NAIT accreditation eventually. Fifty percent of programs required one or more courses in technical writing and 61% (11) required one or more courses in oral communication.

Management related content has long been considered an essential component of NAIT accredited programs. This emphasis was reflected in Table 2 where over half of the programs under investigation required one or more classes in management and operations, economics, statistics and/or supervision. One somewhat surprising finding was that only two programs required courses in project management, which

Table 1. Required Courses in Mathematics and Professional Communication Skills

	% Programs	Median Hours	Mean Hours	Range hours
Mathematics	100% (18)	6	6.9	4-10
✓ Trigonometry	28% (5)	3	2.6	2-3
✓ Calculus	44% (8)	3	3.9	3-8
Oral Communication	61% (11)	3	3.7	2-6
Technical Writing	50% (9)	3	3.2	2-6

n = 18

Table 2. Required Management and Business Related Courses

	% Programs	Median Hours	Mean Hours	Range hours
Management & Operations	72% (13)	3	3.9	3-6
Economics	61% (11)	3	3.3	3-6
Statistics	61% (11)	3	3	
Supervision	50% (9)	3	3.2	3-5
Accounting	39% (7)	3	3	
Safety	33% (6)	3	3	
Quality	33% (6)	3	3.5	3-6
Marketing	11% (2)	3	3	
Project Management	11% (2)	3	3	

n = 18

rapidly is emerging as an important management emphasis area in computer technology related programs.

Table 3 illustrates a heavy emphasis on applied technologies and a wide range of focus areas, when it comes to the application of these technologies. Eighty three percent (15) of the programs reported one or more required courses in microcomputers, but the range of credit hours required varied from three to 12 credit hours. Seventy two percent (13) of the programs required one or more courses in electronics, but the range of credit hours required varied from three to 27 credit hours. Seventy two percent (13) of the programs required one or more courses in digital electronics, but the range of credit hours required varied from three to 15 credit hours. Similar patterns in range for the number of required credit hours existed across most of the technical course topics identified.

The following sections present the key program characteristics that were identified through the qualitative data collection processes. These characteristics include, but are not limited to certification, accreditation, placement, and differentiation/political issues.

Certification. The computer and networking industry has established standards and certifications throughout the last decade that closely align with the qualifications expected of graduates of computer technology-related programs. The practice of teaching to these certifications has been introduced and widely adopted, particularly by two-year community colleges. Many community colleges have developed certification preparation courses with content driven by the certification requirements. As four-year institutions have established computer technology type programs, questions have been raised about the appropriateness of aligning curriculum with certification requirements, or whether computer curricula should be developed apart from those certifications.

Three major patterns emerged from the interviews on this issue. First, for three (17%) programs, the curriculum was driven at least in part by certifications, with certifications being a requirement for graduation. For a second group of 11 (61%) programs, students were allowed or encouraged to obtain certifications, but these were considered to be extra curricula activities. With this group of programs, the extent of emphasis on certifications ranged from strongly encourage certifications to accept them if students wish to pursue them on their own account. With a final group of four (22%) programs, little to no emphasis was placed on pursuing any type of certification, with a strong focus instead being placed on more theoretical or general course material.
Of the 10 types of certification that were mentioned during the interviews, only 4 were mentioned repeatedly. Those four (4) in order of frequency were CCNA (Certified Cisco Network Associate), (13 times), A+ (6 times), MCSE (Microsoft Certified Systems Engineer) (3 times), and Network+ (3 times).

Accreditation. Accreditation is another topic that reflects the relative infancy of the field as well as the diversity of philosophies that exist within these emerging programs. Since this study was specifically designed to investigate programs housed primarily in industrial technology departments (or that have similar roots/configurations), it should not be surprising that most programs included in this study were NAIT accredited (14 out of 18). The remaining programs were not accredited. The responses on this item can roughly be categorized into two types: *happy with accreditation* and *have considered different accreditation*. A total of seven respondents indicated that they were very happy with the NAIT accreditation and that they were not planning to seek any other type of accreditation. Interviewees from these programs opined that NAIT is meeting their needs and that a different type of accreditation would not enhance or improve their program. One respondent discussed specifically the value of the strong management emphasis in NAIT accredited programs while another referred to the long, positive history with NAIT. Yet another individual indicated that NAIT accreditation has facilitated a serious examination of the entire program, with faculty enhancing the program by implementing NAIT visiting team members' suggestions. Finally, a forth respondent indicated that the primary benefit of the accreditation process had highlighted the need for additional staffing.

Seven respondents (from NAIT accredited programs) indicated that they had discussed the relative advantages and disadvantages of pursuing an accreditation other than NAIT. ABET (Accreditation

Table 3. Required Technical Courses

	% Programs	Median Hours	Mean Hours	Range hours
Micro- Computers	83% (15)	3	4.7	3-12
Electronics	72% (13)	9	10.7	3-27
Digital Electronics	72% (13)	3	5.1	3-15
Networking	61% (11)	6	6.8	3-15
Programming	61% (11)	4	5	3-11
CAD	50% (9)	3	3.6	3-7
Controllers	44% (8)	6	5.6	3-9
Telecommunication	39% (7)	3	6.9	3-19
Data & Communication Management	39% (7)	3	6.4	3-18
Web / Internet	28% (5)	3	3	
Wireless Systems	17% (3)	3	3	

n = 18

Board for Engineering and Technology) and TAC-ABET (Technology Accreditation Commission) accreditations were most commonly mentioned. Some noted that the national recognition and status of ABET accreditation could serve as a more effective marketing and job placement tool for graduating students than NAIT accreditation. Some noted that ABET has stringent requirements regarding the types of courses to be taken (e.g., mathematics requirements) and faculty credentials (e.g., requiring engineering or engineering technology backgrounds), which might not be appropriate for these programs. Some faculty felt that neither NAIT nor ABET/TAC-ABET guidelines are designed to meet their needs. Two individuals expressed an interest in the emerging SITE (Society for Information Technology and Teacher Education) accreditation, which is not a currently available option. Faculty from several similar programs across the country have begun to meet in an attempt to develop a set of criteria that could evolve into a new type of accreditation.

Of the four non-accredited programs, one stated that they intend to seek NAIT accreditation, but are not yet ready. A second one is considering accreditation, but is waiting to see what happens with SITE. The third program is considering either SITE or ABET, while the fourth is not anticipating any accreditation, feeling that accreditation is unnecessarily restrictive and limits flexibility in a rapidly changing computer technology field.

Program Differentiation/Politics. One of the key issues faced by computer technology related programs has to do with how they are differentiated from (or similar to) other existing computer-related programs on campus (i.e., computer science, business information systems, computer engineering, etc). This issue is important, particularly for administrators, who must make critical academic and resource decisions. Ninety four percent (17) of the programs in this study were found to be coexisting on their campuses with computer science programs, 78% (14) on campuses with management/business information systems programs, and 22% (4) on campuses with computer engineering programs. Eleven of the programs are located in Schools or Colleges of Applied Sciences and/or Technology, two were located in schools or Colleges of Engineering, one was located in a College of Business, one with computer science and three were located in schools or Colleges of Science. Some programs reported that they share selected courses with computer science and/or information management programs. A small number indicated that their students either obtain a minor in the other program area or that the programs offer a minor in their own program for other computer-related programs across campus. Some programs (4) can legitimately be considered joint programs.

It was expected that many programs would report a history of contentious turf and political issues, particularly with computer science and information management systems programs from across campus. Long-established, computer science, computer engineering, and business information systems programs could have perceived the recent establishment of industrial technology related computer technology programs as an invasion of their established territories. One of the surprising findings of this study was the relatively small extent to which these turf issues exist. Generally, this study's respondents indicated that there is no real competition for students as yet, since enrollments in all similar programs are high. However, some indicated that students are occasionally confused about which type of program might best fit their needs. Programs sharing some joint component with computer science or business information systems programs did not report any political issues at all. One program, noting a history of political problems, attributed them to college location and inadequate administrative leadership.

As would be anticipated, when political issues occur, they typically emerge during the initial stages of program approval. As more computer technology related programs have become established and when turf related disputes arise, it has proven helpful to be able to point to models from other universities where computer technology related programs have been successfully established. When turf issues occur, they often stem from fear of competition for relationships with industry organizations and partners, competition for common grants and other resources, and/or disputes over curriculum content "ownership". Curricular issues commonly arise from a lack of understanding that, while some content may be similar, the emphasis is usually quite different. Specifically, most respondents indicated that their industrial technology based programs approach the content in a much more applied manner than do other computer oriented programs on campus, where the approach is more theoretical. In at least two other instances, the industrial technology program was prevented from offering a course (programming) that was perceived to be too closely related to computer science.

Placement. One major criterion used to measure the quality of a program is its placement rates. This is particularly true for newer programs that are in the initial stages of building positive relationships with industry and local employers. Placement rates were generally reported as good (often in the 90-100% range). However, due to the recent decline of employment opportunities in local computer-related industries, half the programs either reported declining placement rates, or that at the very least, students were harder to place when compared to historical highs. Most respondents noted that this was particularly true for mediocre students. They also indicated that most students are still able to obtain jobs, but the period of time required now takes longer. Sixteen percent (3) programs reported declines in recent placement rates of 20 % or more. Three programs were so new they have had too few graduates to establish placement rates.

However, some placement news was more optimistic. Two programs indicated that their placement rates had remained stable throughout the past few years. One respondent indicated that their placement rate was actually increasing! Not all participants reported the types of jobs graduates obtained. The job types reported by job title are presented in Table 4.

Internships. A total of four programs reported that they require internships. These internships may take on different forms and configurations, with one program requiring three internship experiences beginning at the end of students' sophomore year. The internships commonly cover a broad array of skills and knowledge, ranging from work at a computer help desk, to working with computer hardware, and network support/administration as well as instrumentation and process control areas and electronics. For 13 programs, internships are optional. Sixty one percent (8 of 13) of programs with optional internships reported that from three to ten percent of students participated in internships. Only one program reported that as many as ninety percent of student obtained internships. Only one respondent indicated that they did not encourage students to obtain internships due to large enrollments and a lack of resources.

Problems with internship placements were a common theme throughout the interviews. Specifically, nine programs reported that their students had experienced some increase in problems with finding internships due to the recent slow down of the economy as well as issues related to program configuration or campus location. Three programs reported no problems finding internship opportunities for the students who were actively seeking an internship. Other problems discussed included such concerns as: (a) managers in industry were often reluctant to hire sophomores for internships; (b) industry was hesitant to allow interns to work on sensitive networking equipment; and (c) local industry often not "well-educated" about what students from computer technology related programs were capable of doing. The latter issue was reported by faculty from two programs, both of which are relatively new.

Hiring New Faculty. The respondents were asked a number of questions concerning the challenges associated with hiring new faculty members in the computer technology related areas. With few exceptions, respondents indicated that they had hired new faculty in recent years and that the process had been challenging. The most significant challenges had to do with the escalating academic qualifications (i.e., the doctoral degree) combined with having the necessary technical and pedagogical background. These factors, combined with the competition with the salaries that can be obtained in the private sector, were posing significant challenges to hiring qualified faculty, particularly into tenure-track lines. Regarding academic background, most respondents noted a lack of a "pipeline" to deliver faculty with backgrounds appropriate for computer technology related programs. As would be expected, faculty were coming predominantly from engineering and computer science. The most serious challenge overall was with finding individuals with appropriate terminal degrees who possess a solid technical background, and who are willing to work for $60-75,000 per year.

Future Directions. When asked about future directions for their programs, responses fell into two general categories. First, a number of program representatives discussed accreditation related issues, primarily having to do with questions of which accreditation standards were most appropriate for the computer technology related focus emerging from NAIT-related programs. Furthermore, there were concerns about how employers differentially recognized various accreditation affiliations. Several respondents indicated that employer recognition demonstrated through hiring preferences may have driven them to consider pursuing ABET accreditation for the future. A second major area that emerged from the interviews had to do with curriculum and program changes. Among the areas mentioned were an increased emphasis on wireless technologies, network control systems, security systems, telecommunications, systems integration, and database management. When asked about barriers to progress, the most frequently identified factors were a lack of sufficient resources, the difficulty of locating qualified faculty and, occasionally campus politics.

Implications and Discussion

The authors believe this study represents one of the first benchmark studies of computer-related programs to be conducted in this field. Benchmarking at the university program level has the potential to assist in deciding the future of new and/or existing programs as well as the ability to inform decisions about modifications to existing programs (McGregor & Attinasi, 1998). While

Table 4. Types of jobs program graduates have acquired.

Job Titles	Job Titles	Job Titles
Network/systems administrator	Manufacturing engineer	Electronic department manager
Network developer/designer	Test engineer	Computer support
Network engineer	Field service engineer	Team leader
Network supervisor	Applications engineer	Telecommunications network designer
Entry level systems analyst	Technical support engineer	Control systems engineer
Electronic technician	Instrumentation specialist	Process engineer
Manager	Web developer	Data administrator
Production supervisor		

computer-related programs are still relatively new for the field, sufficient amounts of experience and progress have coalesced to make this an important juncture for conducting this type of research. The following observations summarize the essential points that emerged from this study.

- A consensus appears to be emerging that, while some considerable overlap in content exists among the various academic computing programs, that the industrial technology oriented programs are more applied and "hands-on" in nature than programs in computer science, computer engineering, etc. where the emphasis is more theoretical. This closely parallels the relationship that has existed for many years between industrial technology (more applied) and engineering (more theoretical). Overall, turf issues were remarkably infrequent in the study.
- In general, several areas of emphasis appear to be emerging within the computer technology related programs, including (a) hardware/electronics, (b) telecommunications and systems network management, and (c) programming and data systems management. While each of these was present in all programs, the degree of emphasis appeared to be related to the needs of local industry and employers. In the future, computer technology related programs must continue to refine their curriculum to meet the demands of the workforce and to solidify their niche within the academic computing area.
- One of the most pressing issues that emerged from this study had to do with accreditation. Leaders of NAIT accredited computer technology related programs need to engage in serious dialogue with one another and, potentially with ABET and other agencies, to define and refine accreditation guidelines to provide guidance to the computer technology area.
- Programs overall are growing and faculty are optimistic about future growth. This is encouraging since much of this growth has occurred during a time of economic downturn and upheaval in the computing industries.
- A lack of resources, coupled with the challenges associated with hiring qualified faculty at competitive salaries, were issues for many respondents in this study. Programs continue to grow and improve, perhaps due to the resourcefulness, ingenuity and commitment of computer technology related faculty. In spite of these challenges, there was considerable optimism for the future.

The labor market will continue to demand a more academically and technically diverse workforce. It is clear that the workforce of the future will include some form of computing technology. Employers increasingly hire individuals who have skills, experiences and knowledge that distinguish them from those of other job seekers. Proactive computer-related industrial technology faculty are in a unique position to prepare students to meet these workplace demands.

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