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THE IMPACT OF SKILLS STANDARDS ON THE COMMUNITY COLLEGE MANUFACTURING CURRICULUM

By

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ABSTRACT

THE IMPACT OF SKILLS STANDARDS ON THE COMMUNITY COLLEGE MANUFACTURING CURRICULUM

By

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This is a study of the manufacturing curriculum in Michigan community colleges. During the last ten years we have seen the development of national skill standards intended to influence how students are prepared for skilled trades and manufacturing technician positions. Also during this same time period the manufacturing industry has been battered by another extreme business cycle that threatens the existence of some manufacturing sectors. Because the community colleges have become the primary training and education resource for the manufacturing industry, much interest is placed on the ability of the community colleges to sharpen their focus on meeting the training and education requirements of the modern manufacturing company.

Although these skills standards are working their way into the community college curriculum, wholesale adoption of these standards is not occurring. To better understand the driving forces behind curriculum reform, this study investigates the current state of the manufacturing programs in Michigan community colleges and attempts to clarify the process of curriculum reform.

DEDICATION

Education has become a way of life in my family during these past seven years. While our four children are in the middle of their formative schooling years I continue to work towards my doctorate. Thanks to my wife Brenda for patiently keeping us all on track and providing a nurturing atmosphere for the family. Thanks to everyone in the family for learning to share our limited resources of time, tuition dollars, computers, and office space.

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Chapter 1

INTRODUCTION

The purpose of this study is to evaluate the impact of national skills standards on the community college curriculum. More specifically, this study attempted to define the role of metalworking skills standards in reforming the curriculum in Michigan community college manufacturing programs. The results of this study provide a clearer understanding of how the community college curriculum is influenced by external industry standards and expectations.

Manufacturing remains one of the primary economic resources in the state of Michigan. Much effort goes into keeping the manufacturing workforce trained and educated to meet increasing global competition. The 28 Michigan community colleges continue to provide a large portion of the educational support for this workforce, especially in the areas of metalworking and machining. As the workplace continues to evolve, the community college programs need to reflect the training and educational needs of world class manufacturing companies. Although many factors influence the learning environment in the community college – facilities, instructional quality, student support services - the curriculum stands out as the educational centerpiece of a given program of study.

Problem statement

The highly publicized *Nation at Risk* report in 1983 (NCEE, 1983) generated widespread concern over the K-12 school system. Although technical skill level requirements of employers were increasing, the skill levels of high school graduates were decreasing. This report initiated the first wave of educational reform programs designed to combat the trends of decreasing student competency (Beard, 1993). Initially, institutions of higher education remained largely unaffected by the demand for educational reforms. Ten years later another report, *An American Imperative: Higher Expectation for Higher Education* (Wingspread Group, 1993), pointed out concerns about the condition of undergraduate college programs (O'Banion, 1997). This report indicated that college curricula did not establish clear expectations for student performance (Stark and Lattuca, 1996). Although some college degrees are designed to prepare students for state or national certification exams in areas such as engineering or health care, many general college degrees do not guarantee minimum standards of general academic or analytical skills.

Three reasons exist for focusing this study on the manufacturing curriculum in Michigan community colleges. First, community colleges represent an increasingly significant portion of undergraduate education. National statistics point out that over 44% of all undergraduate students are enrolled in community colleges (Phillippe, 1998). Other estimates indicate this figure could soon be approaching 50%. Jacobs (2001) found that 78.5% of vocational college students are enrolled in community colleges. Although some four-year colleges and for-profit schools offer vocational training, the community colleges continue to be the institution of choice for workforce training and education.

Second, the manufacturing sector remains a major employer in Michigan, employing 18.7% of the workforce in 1999 (MEDC, 1999). Many of these jobs offer the high wages and liberal fringe benefits that drive the Michigan economy. This sector has declined somewhat in the past few years because of economic downsizing and outsourcing. However, the remaining manufacturing companies continue to evolve with new technology and a more efficient approach to production and quality. The shrinking manufacturing workforce in Michigan is partially a result of large productivity gains and greater employee efficiency. These manufacturing jobs utilize a highly skilled workforce that often requires some level of college coursework. Traditionally the community colleges have provided much of the apprentice training for manufacturing companies. More recently community colleges have provided training and course work for the computers and software commonly used on the manufacturing shop floor (Jacobs, 2001). Associate degrees from community colleges provide manufacturing employees with opportunity for occupational advancement through promotion or educational advancement in baccalaureate programs (Grubb, 1999). The long tradition of support and cooperation between community colleges and manufacturing companies will continue to strengthen as the need for a highly trained and educated workforce intensifies (McCabe, 1997).

The third reason that this study focuses on the metalworking skills curriculum is that this area has a visible skills standard on which to focus. A skills standard for metalworking has been completed and made available for use in higher education. The National Institute of Metalworking Skills (NIMS, 1998) is an organization committed to the development and implementation of skills standards for the metal working portion of the manufacturing sector. These skills standards were developed during the mid 1990's and draw from a large cross section of trade associations and industry representatives. The NIMS standards were written with specific performance measures, defining levels of individual attainment in various categories.

The NIMS skills standards are not a replacement for existing metalworking curricula. They exist as a useful tool for developing a wide variety of student learning experiences. Recent curriculum development efforts in Michigan have emphasized computer based learning activities that can be accessed by the student in a self-paced learning environment (http://www.mistcurriculum.org). Instructional practices based on the NIMS standards could range from traditional lecture courses to Internet based courses. Open-entry / open-exit laboratory experiences can also be designed based on the NIMS standards. Regardless of the delivery method, students are expected to demonstrate a mastery of the skills standards as a result of completing the courses of instruction specified by the metalworking curriculum. As community colleges continue to balance their programs between college transfer students, workforce training needs, and economic development opportunities, the curriculum becomes a primary focus of community college effectiveness (McDuffie and Stevenson, 1995).

The curriculum in Michigan community college manufacturing programs must be updated to reflect the changing nature of the workforce. Bailey and Merritt (1995) explain the recent trends toward the "professionalization of the production worker". In traditional manufacturing companies, employees were expected to perform very focused tasks and activities. Those activities considered new or out of the ordinary were referred to a supervisor or specialist. Additional training or education was only occasionally needed when the employee moved to a new department or job classification. In a "high performance workplace" (p. 4) employees are expected to solve problems, continuously improve processes, and implement new technology in the manufacturing process. Instead of relying on a supervisor or specialist, employees must collaborate to improve the manufacturing process and meet customer specifications. Additional training and education occur both at the workplace and in educational institutions. A broader set of technical skills is required and fewer job classifications exist. As the organizational structure is flattened employees must be more self-directed and assume responsibility for customer demands of quality and on-time delivery (Salzman, 1998).

These new requirements of the high performance workplace challenge the existing curriculum in community college manufacturing programs. The technical skills taught must be modernized and include the latest technology enhancements that manufacturing companies are already utilizing. Perhaps more challenging is the need to create a greater emphasis on the soft skills – oral and written communication, team building, problem solving, ethics, and time management skills (Wells, 1996). Instead of being taught a single set of job skills that could be obsolete in the near future, students must be equipped with skills that enable life-long learning and adaptation to new manufacturing environments. Some experts are calling for a new synthesis of academic and vocational education to prepare the world-class manufacturing employee (Bailey and Badway, 2002). Perin (2000) explains the need to make academic courses more occupational and occupational courses more academic.

In the past, when new skills or competencies were required a new course was simply added to the curriculum. This approach eventually creates a crowded and compartmentalized curriculum. The faculty teach computer skills in a computer lab, writing skills in an English course, and ethics in a philosophy course. The student is left to synthesize all of these competencies in a workplace setting. Adding a new course is something an administrator can easily accomplish. Imposing new competencies and student expectations in an existing course is difficult without the complete cooperation of the instructor.

The changing nature of work applies to many types of technical occupations. Kelley and Weston (1996) document the need for engineering education to teach a core set of soft skills to help ensure graduates will be able to work in a rapidly changing environment. Including these skills creates a challenge to a curriculum already crowded with many traditional technical competencies. As many companies attempt to become more productive with a reduced workforce, employees are expected to be more self- directed and responsive to new technology in the workplace. Although these organizations require greater technical skills, as well as improved soft skills, they are cutting back on internal training programs and employee development (Salzman, 1998). This trend places even greater responsibility on educational institutions for employee training.

Purpose of the study

As manufacturing companies continue to face increased competition from developing countries, they work towards increasing quality and productivity. This continuous improvement effort requires workers with higher levels of education and more focused skills (Faulkner, 2002; Bailey and Merritt, 1995). Employers are increasingly looking for a better return on their investment in higher education through a cohesive curriculum that addresses current workplace competencies (Jacobs, 2001). Salzman (1998) explains, "The economy of the 1990's is generally characterized as one of intense global competition, rapid technological advance, and significant transformation in work practices and firm structure. New job and organizational structures are thought to require greater levels of workforce skill" (p. 3).

A strong case has been built in favor of using skills standards in curriculum development. Pedagogically, skills standards provide a curricular foundation. Stark and Lattuca (1996) list eight important elements of an academic plan. One of the first elements is *content.* Skills standards specify the content upon which the curriculum is built. This specification ensures that a course is relevant to modern industry standards and includes topics identified by a broad spectrum of potential employers. An additional element of an academic plan identified by Stark and Lattuca is *evaluation.* Curricula based on skills standards should have objective evaluation criteria, ensuring that competencies are mastered.

Local industry is encouraging the use of skills standards. Although many individual companies still require specialized training, they recognize that a broad set of skills standards form a common foundation for many industrial employees (NSSB, 2000). The workplace traditionally has relied upon training activities such as apprenticeships and certificate programs more focused than a typical associate degree program. Skills standards help to clarify student performance levels further.

School administrators see skills standards as a method of curriculum improvement. Although curriculum reform is generally recognized as a necessary activity in the community college (Thompson, 1994), administrators may not understand the unique challenges of each program. The individual instructor, on the other hand, might feel powerless to enact curriculum reform when he/she only teaches a few of the courses that comprise an entire program. Stark and Lattuca (1996) stress the importance of an administrator leading the charge of curriculum reform. A set of skills standards provides a framework upon which to build a revised curriculum.

Educational programs based on skills standards may attract additional funding. The same companies seeking educational reform are also influential in persuading local and state governments to provide the occupational programs with additional financial support (Baily and Averianova, 1999). The State of

Michigan has generously supported curriculum development for the new M-Tech centers that operate in the community colleges. One stipulation is that the curriculum should reflect the latest industry skills standards.

Since 1995, over seven million dollars have been invested in developing and promoting the NIMS Metalworking Skills Standards (http://www.nims-skills.org/news/6.htm). Are community colleges aware of these standards? Have the colleges taken these standards seriously? Are these standards evident in the metalworking curriculum design? How has curriculum reform occurred in the community college manufacturing programs? What other factors affect curriculum reform?

The purpose of this study is to determine how, if at all, the NIMS Metalworking Skills Standards have influenced the reform of manufacturing curriculum in Michigan community colleges, and why NIMS has or has not had this effect. Additionally, this study will help explain why curriculum reform occurs or fails to occur in this environment. This study will provide valuable information to community college instructors and administrators who must deal with the process of manufacturing curriculum reform. It will give them a snapshot of what is occurring in Michigan and the current state of manufacturing curriculum reform. This study will give manufacturing professionals an inside look at community colleges and how activities such as curriculum reform actually occur. Additionally this study will help organizations such as NIMS and other skills standards proponents to understand how these standards are affecting community college curriculum. Finally, the results of this study should help policy makers and government officials determine the level of success of the curriculum efforts they continue to fund.

Given the amount of resources allocated towards skills standards and curriculum reform in Michigan during the past 10 years, substantial changes should be occurring in the 28 Michigan community college manufacturing programs. This study will help understand the influence of these skills standards and determine whether or not they encourage curriculum reform. The outcome of this study will help identify the critical components to be considered for future reform initiatives.

This study begins with a census of the colleges to identify the institutions currently supporting a comprehensive manufacturing program. The geographical area and constituency of each college largely determine the scope of a manufacturing program. However, some community colleges serving a mostly rural population still support a strong manufacturing program even though the local job market remains small. At the same time, a few colleges located in industrial communities do not support an active manufacturing program. Reasons for this status include competition from nearby community colleges, severe budget constraints, or a lack of leadership to maintain such a program.

The second portion of the study involves a survey of all the colleges with a manufacturing program to determine the level of support for the NIMS skills standards and the associated curriculum reform activities. This survey provides objective data indicating the general direction of the community college manufacturing programs.

The two site visits included at the end of the study provide a more detailed explanation of how curriculum reform occurs or fails to occur in a community college. Additional interviews and discussions with all of the parties involved in curriculum reform help us understand the complex nature of higher education and the obstacles to change. Figure 1 shows how this study begins with all Michigan community colleges and ends with two individual case studies.

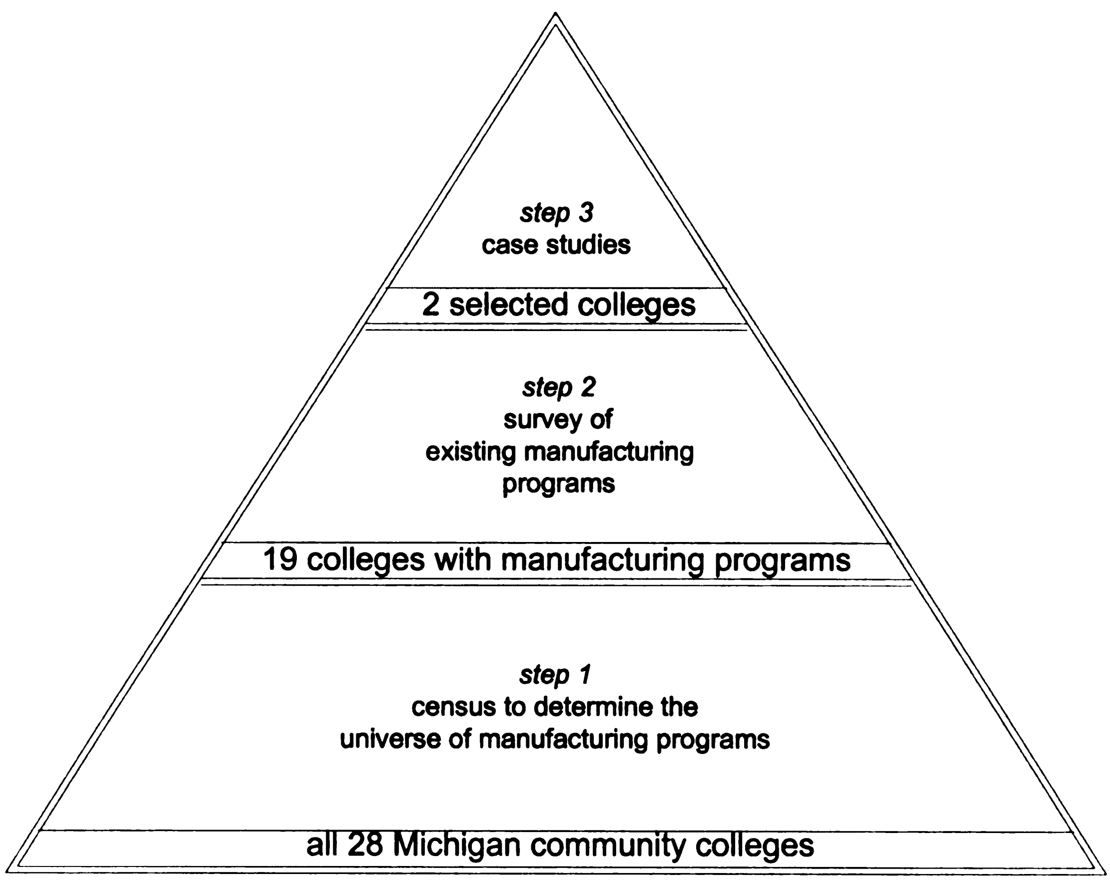

Figure 1: Colleges Included in Each Step of the Study

Limitations of the study

In addition to incorporating skills standards into occupational curriculum, another trend is towards certification of these skills (Bailey and Merritt, 1995). Also known as "credentialing", this movement reflects the need for industry to have something more "certifiable" than a traditional associate or baccalaureate degree. Although the NIMS standards provide the basis for three certified metalworking skill levels, the scope of this study focuses only on curriculum designed for traditional associate degree programs.

Additionally, *formal* curriculum design is the main focus of this study. The curriculum issues will primarily encompass the "official curriculum" in these manufacturing programs. The term "official curriculum" is differentiated from the "null curriculum", the "hidden curriculum", or the "operational curriculum" as related to these programs (Posner, 1992). Whether or not instructors actually adhere to the official curriculum in the community college classroom is a topic for another study.

Chapter 2

LITERATURE REVIEW

This literature review elaborates the following topics to build a conceptual framework and provide a common understanding of the terminology used in this research study:

- Multiple and conflicting roles of community colleges
- Curriculum in community colleges
- Manufacturing related programs at the community college level
- The changing nature of manufacturing companies
- National skills standards
- National Institute of Metalworking Skills
- The role of professional societies and accreditation institutions in curriculum reform
- A proposed model of curriculum reform

Empirical findings from many of the classic community college references, combined with more recent studies and statistics, reveal that the topic of skills standards in community college curricula is part of the long-standing debate over the primary mission of the community college. This literature review helps establish the importance of a comprehensive metalworking program curriculum that effectively prepares students to meet the challenge of today's manufacturing environment.

Multiple and conflicting roles of community colleges

One of the long-standing dilemmas of the American community college stems from the dual role of preparing students for continued college and university studies while at the same time addressing the needs of workforce development. For this reason, many of the contemporary curriculum discussions in the community college are continuations of a decades long debate.

Junior colleges first emerged in the United States in the early 1900s. They were meant to serve as an extension of the college and university system. At the second annual meeting of the American Association of Junior Colleges, this definition was proposed: "an institution offering two years of instruction of strictly collegiate grade" (Cohen and Brawer, 1989, p. 4). A similar definition is given by Bailey and Morest (2004, p. 1) as "providing the first two years of a four-year college education". Some existing community colleges remain steeped in the academic traditions of the junior colleges (Brint and Karabel, 1989). Other community colleges, especially those that began in the '60s and '70s, do not carry the legacy of a strong academic focus.

The initial role of community colleges in preparing students for successful transfer to other institutions is well documented. Knoell and Medsker (1965) studied the success of 7000 community college transfer students in ten states. Most of these students performed academically as well as or better than their counterparts who started out in the university system. This success, combined with the fact that about three quarters of all community college students during the 1960's intended to transfer, is consistent with the academic traditions of community colleges.

Since that time, 2-year colleges have undergone a significant shift in their purpose and mission (Bailey and Averianova, 1999). During the 1950's and 1960's the term *community college* began to replace the original title of *junior college*. Long-term trends pointed towards declining emphasis on transfer students and more interest in occupational studies. As the role of the community college changed to include preparing students - many of them already adults - for careers in technology fields, the size of the colleges and the scope of their programs increased significantly. Although there was initial resistance to these "terminal" vocational programs, in 1970 more than half of community college students were enrolled in career programs (Parker, 1974). By 1993 a record 75% of community college freshmen cited vocational reasons for attending college (Grubb, 1999). This trend reflects the growing need for workers with "some level of college education" below a baccalaureate degree. Grubb estimates that this educational status in the workforce has more than doubled in the past 30 years and will continue to grow.

Dual Curricular Tracks

McGrath and Spear (1991) described the identity crisis of modern community colleges. On one hand, a tradition of academic rigor is upheld for the students who eventually transfer to other institutions. On the other hand, community colleges have been expected to serve a wide variety of constituents, ranging from remedial education to technical training for local industry. This dual role has resulted in a separation of academic and occupational study programs in some community colleges (Cohen and Brawer, 1989). As an example, occupational students take alternative math classes that fulfill program requirements but do not transfer as a credit bearing college math class. Ultimately these dual tracks tend to restrict both the opportunities of the college departments and the students they serve.

Other community colleges have resisted the creation of dual tracks for academic and occupational students. Combining all students in the general education classes causes a different set of problems. Occupational students and those seeking terminal certification may find themselves failing the general education courses that contain a high level of academic rigor (McGrath and Spear, 1991). Similarly, students bound for traditional baccalaureate degrees will not be academically prepared for advanced courses if they must attend classes having open enrollment, or where only a small percentage of students are allowed to fail.

Strong arguments exist, however, to integrate academic and vocational education. Bailey and Averianova (1999) argue that combining academic and vocational education at the program or course level strengthens the overall mission of the community college. Combined programs allow for larger departments and the opportunity to synthesize academic and occupational outcomes. Lombardi (1992) proposes a similar solution – to blend academic and vocational education into a concept of "career education". Perin (2000) further describes the problem of academically unprepared students in occupational training programs. She cites the lack of integration between occupational and academic education. One persistent problem is the watered-down academic class for occupational students, making them ineligible for transfer. This deficiency limits the eventual career choices and opportunity for educational advancement. Another source of tension is the divide between faculty considered primarily academic and those considered primarily occupational: neither group is interested in teaching "the other" material (Perin, 2000, p. 4). Vocational education also continues to suffer from lower status than transfer-oriented course work.

A recent comprehensive survey was conducted to determine the community college faculty view of institutional mission (Brewer, 2000). This study included a survey of over 1700 individuals in 92 institutions. The faculty appeared to be evenly split on the *current* primary mission between workplace preparation (28.1%) and transfer education (27.1%). Additional responses included basic skills training (16.2%) and community service (6.2%). Brewer found that when a similar question was asked about the *ideal* college mission, 33% cited workplace preparation. This study also showed that although predictable differences appeared between academic and occupational faculty responses, both faculty groups agreed that community development activities should not be a high priority for community colleges. In some institutions the expansion of community service activities has created a tension between the "traditional" or "credit" side of the college and the "non-credit" or "customized training" departments. Often separate facilities and employment contracts accentuate these differences.

Funding sources add further complexity to institutional mission. Proponents of a strong academic program point out that traditional transfer courses are more economical to offer – using simple classrooms and large class sizes. They claim that the occupational programs exhaust the college budget with expensive laboratory requirements and high classroom expenses. Those who favor occupational education stress the additional funding available. In Michigan, for instance, vocational students receive a higher level of funding (Lombardi, 1992). Federal funding is also targeted towards vocational education (McCabe, 1997). Perkins Act funds have become a major contributor of laboratory upgrades and new technology in occupational programs (Jacobs, 2001). Additional support from local industry is often intended for vocational programs (Bailey and Morest, 2004). This support comes in the form of surplus equipment and materials donations, scholarships for students in specific training programs, and hiring of program graduates.

The special needs of the adult learner have also added complexity to the mission of the community college. Displaced workers from plant closings and out-sourced jobs come to the community colleges – often financed through a variety of public and privately funded re-training programs. Some community colleges have created special programs for these individuals – recognizing that they come with special needs for accelerated programs with specific objectives for future employment.

Critics of the modern comprehensive community college argue that additional expansion into peripheral activities will distract from the original mission of the community college. Bailey and Morest (2004) completed a study of eight community colleges in five different states. They describe the complex funding and political environments in which these colleges function. The administrators often see growth as an avenue to secure more funding and a stronger support base. However, the core mission of the institution can suffer as the community college tries to be "all things to all people". Although Bailey and Morest explain the obvious pitfalls of the comprehensive community college, they recognize that these institutions will continue to expand into opportunities that support enrollment enhancement and/or revenue generation.

Vertical and Horizontal Expansion

This study examines two special types of community college growth. Vertical expansion is used to gain control of the student population entering and exiting the community college. From the receiving end, programs such as Tech-Prep, School-to-Work, and dual enrollment with high schools have generated additional grants and tuition dollars. This expansion also becomes an effective student recruitment tool. On the other end, vertical integration stresses dual enrollment and articulation with 4-year degree programs in other colleges. This integration is also a strong recruitment tool and enhances the transfer student population. Growth in the horizontal direction includes the many community service and training functions with which community colleges are experimenting.

Again, Bailey and Morest point to increased enrollment, revenue enhancement, and political gains as the primary reasons for horizontal expansion.

Jacobs (2001) points out the inaccurate public perception of occupational training programs. Many of these programs began back in the 1960s and 1970s. These traditional vocational programs were created to fill the large need for entry-level workers in manufacturing and technical occupations. Technical curricula were often considered watered down versions of the academic programs that led to traditional degrees and transfer opportunity. The programs were terminal in nature – meaning that they were separated from the academic programs, and the courses were not meant to transfer into other academic programs. By the late 1990s, these programs mostly had become outdated because of the reduced job market for entry level workers and because the programs did not reflect the changing needs of the high performance manufacturing companies. Another complaint about the traditional occupational programs is that they were inflexible to meet the needs of older adults coming back to update their skills. Jacobs argues for a renewed emphasis on occupational training geared towards emerging new job opportunities and more fully integrated with academic degree programs. Technical curricula must be re-invented as an integrated part of community college academic programs.

These debates over the multiple and sometimes conflicting roles of the community college will likely carry over into the future debates of how community colleges, in their second century of existence, can best serve the needs of their various constituents.

Curriculum in community colleges

Community colleges are flourishing in the United States. Approximately 5.4 million students are currently enrolled in credit classes and another 5 million in non-credit training programs (AACC, 1998). Coley (2000) claims, "as the community college system turns 100, demographic and economic trends would appear likely to increase its vigor" (p. 30). These trends point towards an increasingly important role of the community colleges in the post-secondary landscape of American education. However, the curricula and program perspectives paint a different picture. McGrath and Spear (1991) describe some of the major challenges facing the community college: declining academic standards, diverse and vocal student bodies, less connection with universities, and curricula in disarray.

The meaning of the term "curriculum" can vary greatly among community college constituents. Curriculum could encompass the structure of a single class, an academic program, or the educational activity of an entire school. Stark and Lattuca (1996) define curriculum as an "academic plan... including purposes, activities, and ways of measuring success" (p. 9). This plan should include the following elements: purpose, content, sequence, learners, instructional processes, instructional resources, evaluation, and adjustment.

To help understand its various meanings, John McNeil (1996, p. 115) posits a multi-faceted description of the term "curriculum":

Ideal curriculum. This definition of curriculum refers to the ideology of what should be taught in a given program of study. Several different versions of the ideal curriculum may compete for attention in the actual implementation of the plan.

Formal curriculum. Curriculum at this level will have passed from the ideal state to an academic plan that has been officially adopted and approved by sanctioning bodies. This form of curriculum should be the version published and promoted as a working model.

Perceived curriculum. This concept is what the instructors believe they should be teaching, which may or may not coincide with the formal curriculum.

Operational curriculum. This term describes what happens in the classroom. Again, it may closely resemble the perceived curriculum, or it may vary to a large extent.

Experiential curriculum. Each student may experience the operational curriculum from a different perspective. Student background and previous knowledge may cause individual students in the same program to view the operational curriculum from a different perspective.

These definitions help explain why curriculum change can be such a complicated procedure. The administration may modify the formal curriculum, but classroom and laboratory experiences might not change. Similarly, an instructor may modify the classroom experience without bothering to change the formal curriculum.

From a slightly different perspective, George Posner (1992, p. 12) presents an additional set of curriculum definitions:

Official curriculum: The curriculum described in formal documents.

Operational curriculum: The curriculum embodied in actual teaching practices and tests.

Hidden curriculum: The institutional norms and values not openly acknowledged by teachers or school officials.

Null curriculum: The subject matters not taught.

Extra curriculum: The planned experiences outside the formal curriculum.

These definitions recognize the culture of an institution and the values by which it operates – even if those values are not implicitly stated in the curriculum. In this study, the definitions of the *official* curriculum and the *formal* curriculum best describe the curriculum I examine.

Comparing Curriculum with For-Profit Colleges

One helpful framework for understanding the community college curriculum development process is to compare it to the curriculum development process used by for-profit technical colleges. Bailey and Badway (2002) performed a comparison study between community colleges and for-profit colleges. They noted several important differences in the approach to curriculum development. In the community college, the instructors teaching the courses have more latitude in curriculum and pedagogy decisions. The community college instructors are empowered to claim ownership of the curriculum and to tailor the classes towards the perceived local needs for that class. The for-profit college curriculum is much more standardized. All instructors are expected to adhere to the extensive course documentation. The for-profit institution utilizes a team of experienced faculty and instructional designers to develop this course documentation. The strength of the centrally managed curriculum of the for-profit colleges lies in the ease of use for new and adjunct faculty, the ability to articulate the curriculum with perceived employer needs, and the expectation that all students will receive a similar educational experience regardless of the instructor.

There are more obstacles to curriculum reform in the community college than in the more streamlined hierarchy of the for-profit colleges. Community colleges must often deal with the complexity of academic and vocational outcomes. Bailey and Badway (2002) note that some community college instructors circumvent the lengthy curriculum revision process by teaching different material under the guise of the old course titles and descriptions. This approach is an effective short-term solution but does little to correct the gap between the formal curriculum and the operational curriculum (McNeil, 1996).

Based on the model of curriculum development in the for-profit colleges, embracing a skills standard and teaching to that standard would occur quicker and more uniformly in the for-profit college than in a community college. The for-profit college operates more like a business where decisions are made from the top down and everyone participates in carrying out those decisions. In a community college curricular reform may fail because of instructors who resist change or administrators who fail to follow through on the project.

Comparing Curriculum with 4-Year Colleges

Bailey and Badway (2002) also note that in both public and for-profit 4-year colleges, curriculum tends to be more focused and treated as a "sequence of courses". First, these colleges have more control than community colleges over the caliber of student admitted to the program. To a certain degree they can "pick their winners". Community colleges have much more liberal enrollment policies. Second, a 4-year college has a greater percentage of younger students who follow the prescribed program plan. This plan often involves taking a series of core classes in proper sequence (Thompson, 1994). Community colleges have older students selecting classes to enhance their employability, often raising havoc with the prerequisites recommended in the course catalog. In some cases an adult student will first focus on an area of specialization and then go back to work on degree requirements. Grubb (1999) refers to these students as "experimenters". He explains that community colleges are great low cost places for students to try out various post-secondary learning opportunities. However, this process can result in deceivingly low community college "success" rates because of so many program non-completers. Compared to the more controlled environment of 4-year and for-profit colleges, it is no wonder that community college curricula can appear rather disorganized.

Stiehl and Lewchuk (2002) warn against traditional methods of curriculum development in community colleges: "We have developed curricula within the isolation of the academy, around tables where only the faculty are present. More often than not, our curriculum design process focuses on what new topic should be covered, in which course it should be covered, and which faculty member wants to cover it. It's as if we see ourselves living and working in a laboratory that is separate from our students' lives. It's a process that will no longer survive the scrutiny of our public and accreditors" (p. 2). Thompson (1994) also reminds us of how private industry views higher education as "sheltered enclaves out of touch with reality". One advisory board member interviewed in this study explained that although he really wanted to help the local community college with curriculum reform, he could no longer bear the long meetings where every viewpoint is considered and a consensus is never reached or acted upon.

Resources for Curriculum Reform

Although the duties of curriculum maintenance and revision may be primarily assigned to the community college instructor, the resources to perform this task may be limited. Lombardi (1992) discovered that up to 90% of a community college instructor's time is taken up with teaching and classroom management related issues, leaving little time for curriculum development activities. Community college instructors, usually hired based on a combination of academic credentials and vocational experience, often lack the training and experience in formal curriculum revision (Grubb and Associates, 1999). Finally, the trend towards utilizing more adjunct faculty can detract from an overall concern for curriculum development (Lombardi, 1992). Adjunct instructors are often more concerned with high student course ratings and job security than with curriculum revision.

Grubb and Associates (1999) found that the more comprehensive community colleges tended to become very fragmented, attempting to cover a wide range of services with limited resources. Small department sizes typical in many community colleges mean that multiple responsibilities often fall on the shoulders of a single individual. One instructor explains it this way:

> We face here what I call the community college paradox ... It's that the community college touts itself as being the teaching institution in higher education. It's the one that's not burdened, if you will, by the research assignment for the teacher...What you would expect, I think, is communities of teachers who are developing their skills as teachers, and that there'd be a lot of institutional attention to that very goal...But instead what you find in the community colleges is... teachers who are just phenomenally isolated (p. 50).

Another community college instructor poignantly states his perception of how the administration views his occupational department: "I'm an independent contractor – no one gives a sh__ what I do as long as enrollments are up" (p. 49).

Grubb and Associates (1999) studied the recurring theme of formal curriculum versus operational curriculum. Often a course syllabus is written or a textbook is chosen to match external skills standards or employer expectations. The underlying assumption in developing these curricula is that the many critical instructional components – motivated students, competent instructor, and adequate facilities – are all present. Grubb noted that about one quarter of all community college classrooms observed in the study could fall into the "distressed" category. A distressed class has a low level of connection between the proposed syllabus and the student learning taking place. In some cases the distressed classes are caused by ineffective instructional techniques. Often a distressed class is the result of open admission policies in the community college, allowing unprepared students into the classroom. One method used by instructors to cope with a distressed class is to take the attitude of "blissful indifference". In this context, the instructor plows ahead with the planned course activities, largely indifferent to whether the students are learning the material. At least in this case the course materials are "covered". Another reaction to a distressed class is "accommodation". The instructor reduces the gap between the curriculum and the classroom by lowering expectations. One instructor interviewed openly admitted to selecting a textbook to impress four-year instructors, but then needing to cut back on the material covered. Another instructor commented on the general tendency of loosened standards in his department:

> I think, generally, we're too loose in our standards. Because we want to ... it comes from a good heart ... we want to be forgiving, you know, we want to help students as much as we can, we've got this sort of bleeding heart for all the students. But I think maybe we've gone too far with that, and now its time for a little tough love (p. 223).

With regard to laboratory facilities, Grubb and Associates found in their study that occupational students learn best – and occupational instructors teach best - in the hands-on method of instruction. Students struggle when large doses of classroom theory and textbook readings are substituted for hands-on learning.

Terry O'Banion (1997) proposes several challenges to community colleges seeking to improve curriculum and provide more emphasis on learning. Two fundamental questions that can be asked of new program components are "Does this action improve and expand learning?" and "How do we know this action improves and expands learning?" (p. 9). In other words, shift the focus of curricula to the learning outcomes and objectives. For example, purchasing a new piece of laboratory equipment without addressing these two questions means that money continues to be spent and programs modified without any real measurement of program improvement.

Secondly, he recommends "educational experiences be designed for the convenience of the learner rather than for the convenience of institutions and their staffs" (p. 15). He later follows up with the statement "It is generally acknowledged that the creators or guardians of a program or institution will find the task of making changes formidable" (p. 28). In other words, successful educators will naturally protect an environment to which they are accustomed and in which they are successful. True curriculum reform is more likely when administrative leaders, industry professionals, and instructional designers team up with faculty to help create a more effective learning environment. Finally, O'Banion suggests that all learning outcomes be based on competency requirements that reflect national standards.

Jacobs (2001, p. 182) states, "Increasingly employers are demanding new curricula that include skill standards ... not typically included in traditional curricula." These employers do not trust that the existing faculty-developed curriculum will meet their needs. Jacobs also argues that curriculum development for occupational programs is different than for traditional academic disciplines. In academics, the outcomes are not related specifically to occupational achievement. Occupational programs must be compared to relevant external standards – making sure that program outcomes are updated with changes in processes and technology.

Three Curricular Frameworks

Stiehl and Lewchuck (2002) describe three basic frameworks of curriculum development. *Content framework* includes the traditional methods of describing the content to teach, how to teach it, and how to test on it. A second framework – *competency framework* – reduces learning to hundreds of tiny tasks that can be checked off and recorded as they are mastered. Little synthesis of the skills is required in the competency framework. The *outcomes framework* is more closely matched to what the student will encounter in the workplace. This framework incorporates both behavioral and constructivist theory to help students synthesize skills in authentic projects and tasks. The outcomes framework begins externally by defining what students are expected to do in the workplace. This step will guide the general content of the curriculum, which is then defined in terms of specific skills. Finally, projects to demonstrate these skills are developed along with the appropriate assessment criteria. Stiehl and Lewchuck argue that this third framework – the outcomes framework – is the ideal for modern occupational curriculum development.

The curriculum revision process in traditional 4-year engineering programs faces similar challenges. Kelly and Weston (1996) document the challenge to identify a core curriculum that demonstrates the synthesis of basic engineering skills to the workplace. This task competes with the already crowded curriculum of many fragmented technologies and specializations. Curriculum discussions beginning with what to cut out of the existing courses to make room for a more hands-on practical experience will lead to acrimonious debate and protection of turf. Again, a gap exists between the traditional academic requirements of a degree program and the skills a graduate needs to work in a modern engineering environment.

Elmaraghy and Elmaraghy (1996) expand that argument to include engineering programs in Canada. They recognize a significant academic gap between manufacturing engineering technology programs and manufacturing engineering programs. They acknowledge that the manufacturing engineering technology programs include more of the practical and shop floor skills required in the workplace. Elmaraghy and Elmaraghy recommend that the manufacturing engineering programs be closer aligned with the needs of the modern manufacturing industry. Specifically, they call for "relevant, hands-on, innovative curricula that respond to changing needs in the workplace" (p. 4). In Europe, engineering education has traditionally included closer ties with manufacturing companies and a greater synthesis of academic knowledge with shop floor competencies (Kelly and Weston, 1996).

Felder and Brent (2003) explain that the new ABET accreditation criteria used since 2001 also reflect the trend towards a constructivist – or hands-on – approach to engineering education. The Accreditation Board for Engineering and Technology (ABET) was formerly accused of using a "bean counting" system of assuring that a rigid set of academic topics were covered in a program. Under the new system ABET is much more flexible about program content. Greater emphasis is placed on educational outcomes that reflect current industry standards. Equally important are effective assessment procedures that ensure the competencies are mastered. These new assessment criteria allow for a greater variety in program focus, recognizing the diverse local needs of regional manufacturing companies.

Delta College – A Traditional Curriculum

Finally, in this discussion on community college curriculum I compare the traditional engineering technology curricula with new curricula that have been developed and are in the process of being implemented. Delta College in Michigan offers a two-year engineering technology program that carries ABET accreditation (http:/www.delta.edu/degreesprograms/MechanicalEngineer.asp). The course sequence is shown in Table 1.

Course	Description	Credits
	Fall Semester	
CAD 114	AutoCAD Introduction	2
DRF 104	Basic Mechanical Design	3
MTH 119	Intermediate Algebra	4
MFG 111	Manufacturing Process	3

		12
	Winter Semester	
CHM 107	Chemistry for Engineering Technology	4
DRF 107	Intermediate Mechanical Design	3
LW 220	Lifelong Wellness	1
MTH 113	Applied Trigonometry	4
		12
	Spring Semester	
ENG ___	Any approved college Composition I course	3
LW ___	Any approved Lifelong Wellness requirement	1
MS 113	Machining Processes	2
		6
	Fall Semester	
MT220	Introduction to Fluid Power	3
MT 221	Materials and Metallurgy	3
MTH 208	Elementary Statistics	3
PHY 111	General Physics I	4
		13
	Winter Semester	
EET 235	Electrical Circuits	3
ENG 113	Technical Communications	3
MT 251	Statics and Dynamics	3
MT 255	Kinematics of Mechanisms	3
		12
	Spring Semester	
DRF 257	Advanced Mechanical Design	4
MT 256	Strength of Materials	3
		7
	Fall Semester	
CED 280	Cooperative Education: Mechanical Technology	1
DRF 257	Advanced Mechanical Design	4
GEO 116	Professional Global Awareness	1
MDA 205	Rapid Prototyping and Tooling	.6

MDA 211	Interactive Part Modeling	2.4
PHL 207	Engineering Ethics	1
POL ___	Any approved American Government requirement	3
		13
	Total credits required	75

Table 1: Delta Engineering Technology Curriculum

This very traditional engineering technology program has been designed to meet the graduation requirements of Delta College, the ABET accreditation criteria, and the transfer requirements of baccalaureate institutions. Several of the courses listed are one or more options among general requirements where students can choose based on special interests or prior knowledge. One notation listed with this program reminds the student that the program transfers to a baccalaureate technology degree program but not to an engineering program. This program has expanded well beyond the typical two year / 60 credit program found in most community colleges. Also note that while these course offerings are typical of an engineering technology program, additional offerings have been added to the end of this program. These courses – Professional Global Awareness, Rapid Prototyping and Tooling, Interactive Part Modeling, Engineering Ethics – appear to address the changing needs of manufacturing companies and are offered in a shorter format than the typical 3 or 4 semester-credit courses.

NCE/AME – A "Novel" Curriculum

In 1995 the National Science Foundation funded a large curriculum project of the National Center of Excellence for Advanced Manufacturing Education (NCE/AME, 2000). This project – "A Novel Curriculum for the Associate Degree in Manufacturing Technology" – was housed at the Sinclair Community College and also worked closely with the University of Dayton in Dayton, Ohio. The purpose of this project was "to develop a novel, activity based, competency based, contextual, industry verified, modular curriculum in manufacturing technology that can lead to systematic change in the way technician education is delivered in the United States" (p. 2).

This curriculum project began with identifying leading national skills standards initiatives. The SCANS competencies, developed by the U.S. Department of Labor Secretary's Commission on Achieving Necessary Skills, were important because they are already recognized nationally as universal competencies for all workers. Other standards included the Advanced High Performance Manufacturing Standards, National Institute of Metalworking Skills, and the National Skills Standards Board. Another primary source of recommendations was from the Society of Manufacturing Engineers *Curricula 2002*. This document contained many recommendations for manufacturing curricula, including the associate degree in manufacturing engineering technology. One guiding principle in this project was that a constructivist theory of learning be encouraged through a series of "authentic learning tasks". Another departure from traditional curricula is that learning modules are not based on the traditional semester hours of credit. Instead the learning units are typically smaller and more focused. The concern is primarily competency based rather than time based instructional units. In other words, completion of a module occurs when the competencies are demonstrated rather than when the "seat time" has been fulfilled. Approximate estimation of completion time is obviously needed to plan the learning activities and equate the program to traditional semester hours.

This project began with a compilation of over 800 competencies identified as required for an associate degree in manufacturing engineering technology. From these 800 competencies a list of 175 major headings were identified to help group the competencies. Finally, nine clusters were developed to further organize the major headings. Table 2 shows the organization of the modules.

Introduction to World Class Manufacturing
Manufacturing Processes and Materials
Basic Material Removal
Metal Forming and Joining
Metallic Materials
Non-Metallic Materials
Plastics Manufacturing Processes and Materials
Principles of Manufacturing Processes
Tooling for Manufacturing
Design for Manufacturing
Conceptual Design
Drawing and Sketching
Geometric Dimensioning and Tolerancing

Product Development and Testing
Quality Management
Process Control Quality Foundations
Production and Inventory Control
Consistent Work Methods and Build to Demand Introduction to Just-In-Time (JIT) Kanban and Pull Systems Manufacturing Work Cell Design Process Flow and Lead Time Reduction Principles of Production and Inventory Control
Manufacturing Systems and Automation
Computer Numerical Control Electrical and Electronic Controls Robots and Programmable Logic Controllers
Enterprise Integration
Customer Satisfaction Performance Measures
Mathematics
Basic Statistical Variation College Algebra Applications Describing Position, Velocity, and Acceleration Precision, Accuracy, and Tolerance Statistical Distribution Units and Conversions Vector Analysis
Science
Basic DC Circuits Forces and their Effects
Humanities, Communications and Teamwork

Preparation of Letters and Memoranda
Professional Development
Teamwork
Tools for the Future

Table 2: NCE/AME Curriculum

This innovative curriculum stands apart from traditional manufacturing curriculum in several ways. The curriculum is very much industry driven and the direct linkage between skills standards and module content is visible in the curriculum documentation. Because the modules are competency based, the program is defined more by what a successful participant can do than by what topics were "covered" in a course. Also, the modules employ a high level of integration to assist the learner in applying concepts previously learned. Each module follows an elaborate educational design that begins with a "big picture", introduces specific competencies, and concludes with generalizations and practical examples.

The intent of this curriculum project was to create a national model of manufacturing curriculum reform that could be disseminated to other colleges and universities. Although this curricula design is intended for ABET accreditation, questions remain about how such a radical curriculum design will fit under existing guidelines and expectations. Additionally, articulation issues must be worked out with four-year colleges and universities.

Institutions of higher education are not known for their speed and efficiency in modifying existing courses and degree programs to meet modern industry expectations (Bailey and Badway, 2002). Adopting a national curricular model such as this one may be less painful than reforming existing programs. When seeking NIMS or ABET accreditation it might be easier to start a new program built entirely upon the recommendations and specifications of that organization. However, Bailey and Morest (2004) warn against continued proliferation of new programs. Adding new programs contributes to the complex organizational structures in community colleges. The small department sizes that result from such a broad offering of programs will likely discourage a unified and structured curriculum.

Manufacturing programs at the community college level

Community colleges will continue to play a dominant role in educating the manufacturing workforce needed in the 21st century. Nationally, 78.5% of post-secondary vocational education is found in the community colleges (Jacobs, 2001). As mentioned earlier, targeted funding often follows these occupational students. Manufacturing companies need more skilled workers to continue their growth in high technology tooling, production, and assembly. Additionally, the anticipated retirements of skilled workers in the next five years requires preparation of a new workforce. Although the number of jobs requiring a four-year degree or greater has stabilized in the past few decades, many more jobs now require between 6 months and 2 years of post-secondary education (McCabe, 1997).

Community colleges are faced with many challenges in their role as the premier educational institution for world class manufacturing companies. Many businesses have been forced to undergo radical changes in the past few decades to meet the pricing and quality demands of the international market. During this time community colleges have remained largely unchanged (Beard, 1993; Stiehl and Lewchuck, 2002). Colleges and universities are often viewed by manufacturing companies as institutions that suffer from poor management, duplication of programs, and lack of relevance to the workplace (Thompson, 1994). In many cases local industry groups are taking the lead in promoting change in educational institutions. According to Robert Knight (1998), private industry councils are using their economic and political clout to direct funding towards programs and curricula that support the workforce development needs of their companies. These efforts are forcing community colleges to improve their workforce development activities or concede a portion of their funding and student population to agencies successful in these pursuits.

In the mid 1990's a consortium of West Michigan manufacturing companies spent substantial amounts of time and resources trying to articulate their workforce training needs to the local educators (Right Place Program Manufacturer's Council, 1996). They focused on Total Quality Management, a cornerstone of international competition. The manufacturer's council challenged educational institutions to apply these same principles of continuous quality improvement and documentation of quality. These procedures, as applied to higher education, include having standardized educational goals that drive teaching and testing standards. Some proponents of this approach challenge the colleges to guarantee competent graduates, offering free remedial education if students fail to meet the standards.

Although national skills standards provide the basic framework for curriculum development, local community colleges need to filter these standards to reflect the local employer needs. Jacobs (2001) notes that the selection of specific software or process knowledge should reflect the needs of local industry – even if this means teaching several alternative technologies at the same time. He further explains that because vocational curriculum is externally dictated, the issue of "maintaining relevance" becomes central to the success of post-secondary occupational education. As a result, vocational curriculum must be updated and modified more often than traditional academic curriculum. When this reform fails to occur, the result is a shortage of skilled workers and declining enrollments in occupational education.

Community colleges are also faced with maintaining a system of degrees and credentials meaningful both to local industry and to other colleges and universities. Because many community college students are part-time or enrolled in non-credit programs, the community colleges are faced with the challenge of establishing a broad framework of matriculation, certificate completion, and job related competencies that allow the students to move toward long term goals of degree completion and career enhancement (McDuffie and Stevenson, 1995).

Finally, Jacobs (2001) encourages community college faculty and administration to focus on updating their industry skills and knowledge, and to revise the curriculum as needed. He acknowledges that the increasing comprehensiveness of the community college results in many fragmented occupational programs with limited resources to excel in any of the programs. As economic resources become scarce, some occupational programs may have to be eliminated or combined with others to remain viable. An emphasis on workforce competitiveness helps provide a convincing argument for continued support of community college vocational training (Bailey and Averianova, 1999).

Community colleges remain among the most cost effective and accessible employee training services for manufacturing companies. McCabe (1997) elaborates several of the reasons why community colleges will continue to dominate in workforce development needs. Michigan's 28 community colleges are located within commuting distance for a large majority of the population. Accessibility is very important to students geographically bound because of employment or family situations. In rural areas much more is being done with satellite campuses and distance learning to include everyone that needs training.

Community colleges have the right values and attitudes to encompass the learning needs of all individuals – not just those with successful academic credentials. Learning opportunities include a wide spectrum of certificates, degrees, apprenticeships, and workforce skills. Non-credit training and community service activities comprise a large portion of community college activities. Included in these programs are a wide variety of services such as testing and basic skills instruction, placing the learner in an appropriate environment.

Community colleges are also effective in workforce training because they are flexible and responsive to new developments and technologies. Closer involvement with local companies helps them stay abreast of new training opportunities. As businesses look for ways to cut training expenses they realize the low cost of community colleges compared to universities or private training providers (McCabe. 1997).

Finally, community colleges reaching out to all individuals needing continuing education provide a concrete foundation upon which participants can advance their careers or opportunities for college degrees. For example, a course taken for personal interest might eventually apply towards an apprenticeship or certificate. That group of certificate courses could be counted towards an associate degree, which would then provide an opportunity to pursue a baccalaureate degree. Community colleges are responsible for developing curricula centered on real workplace competencies that can be measured and that will satisfy the increasing skill levels required of the workforce in the 21st century.

The changing nature of manufacturing companies

Manufacturing has always been a major wealth-creating element of the U.S. economy. For many decades during the mid-1900s, our nation's dominance in manufacturing was almost taken for granted. Although it was largely responsible for the growth of middle class America, manufacturing was also characterized as dark, dirty, dangerous work that many young people wanted to avoid (Wells, 1996). During the 1970s, the U.S. experienced its first real threat to manufacturing dominance. Japan, long known for cheap transistor radios and consumer trinkets, suddenly started to dominate the machine tool business and began making in-roads in the automobile industry. American companies responded with a renewed emphasis on quality and efficiency, emerging in the early 1990s as more competitive and better attuned to the world marketplace.

The economy of the 1990s experienced unprecedented growth. However manufacturing suffered from several unusual pressures (IRN, 2002). One problem was finding enough skilled employees to run production during the years of record employment. Another problem was that manufacturing was suffering from extremely low status in the eyes of investors and the American public. Manufacturing companies were providing consistent returns of about five percent while the "dot.com" companies were increasing their annual net worth at 2 to 4 times that value. Some manufacturing companies succumbed to short term strategies for raising investor values while at the same time harming their long-term competitiveness (Right Place Program Manufacturer's Council, 2002).

The significant loss of high paying manufacturing jobs during this last recession caused a renewed interest in manufacturing. According to Wells (1996), the "wealth-transferring service sector of the economy is a product of healthy growth in the wealth-creating manufacturing sector" (p. 1). In Michigan manufacturing still accounts for 25% of the state payroll and 93% of exports (Right Place Program Manufacturer's Council, 2002). More than just another business cycle, many manufacturing jobs have been lost to foreign competition and will not likely return. One of the major inequities manufacturers face is the cost of labor. Any manufacturing operation that remains labor intensive is at risk of being outsourced. The legacy costs of large American companies are prohibitive – pensions, health care, and unfair tax structures put them at a disadvantage in the world marketplace (Right Place Program Manufacturer's Council, 2002).

The problem is more complex than simply lowering costs. Some emerging countries have aggressively targeted prime industries such as tool and die. For example, Portugal has concentrated on mold making. Almost 90% of the molds they build are exported – 18% to the United States (IRN, 2002). These foreign competitors are heavily supported and subsidized by their own governments. American companies are asking for additional government support in research, training, and education to help them compete in this uneven playing field

Manufacturing companies that compete internationally continue to face several major challenges. Automation and sophistication of manufacturing processes will continue to drive up productivity and drive down labor costs. Product innovation must continue at a rate that causes planned obsolescence before a design can be copied and imitated in a developing country. Manufacturers must form strategic alliances with emerging third world countries to capitalize on opportunities in the world marketplace (IRN, 2002).

Although some manufacturing companies anticipate a promising future as the economy strengthens, real growth in manufacturing jobs is not guaranteed. Manufacturing companies will continue to shed from their workforce employees marginally equipped to work in this new environment. Many companies have learned to get by with fewer employees, adopting lean manufacturing techniques and working with a flatter organizational structure. New employees must have both current skills for existing technology and the ability to adapt to new technologies introduced on the shop floor. In addition to technology skills, a new emphasis is being placed on soft skills such as communication, teamwork, and problem solving. These pressures for a higher skilled labor force challenge community colleges to update curriculum and train to the new production technologies as they become available (Jacobs, 2001).

National skills standards

In 1994 Congress passed the National Skills Standards Act, establishing the National Skills Standards Board (NSSB) for the purpose of developing a comprehensive system of workplace standards for American industries. National skills standards create a set of workforce specifications that describe the skills and knowledge desired by employers for workers in a specific occupation. Fifteen strategic industry sectors were identified, one of these being *Manufacturing, Installation, and Repair.* In further defining the purpose of these skills standards, the NSSB states, "Educators can use skills standards to create curriculum that better prepares students for work" (NSSB, 2000, p. 2).

Susan Faulkner (2002, p. 1) describes the emergence of national skills standards and their intended impact upon education and industry:

> For more than a decade, representatives from industry and labor organizations, educators, training providers, and civil rights organizations in the United States have been developing a voluntary system of nationally recognized industry validated skill standards, assessments, and certifications. The underlying premise is that clear articulation of skills and knowledge required by front-line workers in high-performance environments can serve as a benchmark that workers and businesses can use to maintain a competitive advantage.

Supporters believe that skill standards can promote flexibility and portability of a worker's skills across occupations, industries, and geographic areas. This preparation will improve the fit between what is learned in school and what is needed on the job (NSSB, 2000).

Jim Jacobs (2001, p. 183) describes the potential for these skills standards: "The National Skills Standards Board release of the manufacturing skill standards also underscores the desire of employers to encourage the development of curricula responsive to their own needs, not waiting for educational institutions to develop programs." He further explains that these skill standards "call into question not only traditional occupational programs and courses, but who bears responsibility for producing the curriculum and the role of the faculty in the assessment process" (p. 183).

Bailey and Merritt (1995, p. 1) observe, "The skills standards movement has emerged from a conviction that technology and market changes have caused significant modifications in the types of skills and behaviors needed by workers on the job. This conviction has motivated a broad education reform movement that involves changes in curriculum and pedagogy and seeks to tie education more closely to the emerging needs of the workplace." Susan Faulkner (2002, p. 2) explains the connection between industry based skills standards and community college curriculum as follows:

> Skill standards are made up of a work-oriented component and a worker-oriented component. The work-oriented component focuses on the requirements of the work, describing what needs to be done on the job and how well it must be performed. The worker-oriented component describes the knowledge and skills an individual needs to possess in order to do the work competently. Recognizing that education and training are driven at local levels in ways that meet local needs, the NSSB has neither the authority nor the intention of developing curricula and instructional materials at the national level. The organizational framework for the development of a skill standards system and the common language and format developed for the academic and employability knowledge and skills used by the NSSB could be a cornerstone for curriculum development.

Bailey and Merritt (1995) explain that a short-term goal of skills standards is to improve the communication between students (i.e. prospective employees) and the employers. This connection helps de-mystify employer needs. Skills standards seek to reform the relationship between work and education, ensuring a long-term partnership dedicated to keeping education in tune with current needs in the workplace.

In a follow-up paper Merritt (1996) describes two distinct models for skill standards implementation. The first model – the skill components model – focuses on the integration of skill standards as a narrowly defined set of workplace skills required to perform a job in a traditional hierarchical organization. Academic skills are not strongly integrated into this model. A more comprehensive model – the professional model – seeks to combine the technical and academic skills needed to perform complex tasks found in the emerging workplace. This model addresses the uncertainty and changing environments upon which the high-performance workplace is based.

Many studies show that manufacturing employees today require greater professional skill levels (Faulkner, 2002; Jacobs, 2001; Right Place Program Manufacturer's Council, 2002). Ironically, Salzman (1998) reports that some large employers are cutting back on their workforce training and development programs. The concept of lifelong employment, where individuals are placed into apprenticeship programs and company sponsored job skills training classes, has been replaced with a trend toward using contract workers and out-sourcing. Instead of a narrow set of skills that formerly guaranteed lifetime employment with a single company, workers must be trained in skills that can be more easily transported between employers and across jobs within the same business or industry.

Salzman also warns about oversimplifying the supply (educational institutions) and the demand (employers). Although community colleges appear poised to take on the workforce skills training needs of businesses, they must not neglect their role of providing a well-rounded education toward lifelong employment. Focusing only on the short term needs of employers will short change students preparing for long-term careers and for additional college coursework.

During the past 10 years, the skills standards for manufacturing have progressed from a conceptual stage to a full set of documents ready for implementation. The manufacturing industry has now established a common knowledge base fundamental to all employee training and development requirements (Parry, 1996). Instead of trying to satisfy the needs of a few vocal businesses, educators can now access compiled and verified sets of competencies with which they can align their curriculum.

National Institute of Metalworking Skills

Coincident with the work of the National Skills Standards Board, the non-profit National Institute of Metalworking Skills (NIMS, 1998) set out to develop and implement skills standards for the metalworking portion of the manufacturing sector. A consortium of metalworking trade associations, national labor organizations, council of state governors, metalworking companies, and educators helped to create NIMS. The effort to write skills standards and develop credentialing and program accreditation was funded by the associations listed below:

- American Machine Tool Distributors Association
- Association for Manufacturing Technology
- Council of Great Lakes Governors
- National Tooling and Machining Association
- Precision Machined Products Association
- Precision Metal Forming Association
- Society of Manufacturing Engineers
- Society for Plastics Engineers
- Society of the Plastics Industry, Mold Makers Division
- Tooling and Manufacturing Association

These skills standards were developed over the past decade using focus groups of industrial trainers, human resource managers, and skilled trades persons. Skills standards are written with very specific performance measures. These standards spell out various levels that individuals can attain at certain points in their education and work experience (NIMS, 1998). Many standards were created for various occupations in metalworking, providing the opportunity to link curriculum directly to competencies that can be tested and measured. NIMS primary activities include:

- developing, writing, validating, and maintaining skills standards;
- credentialing individuals to specific skills standards;
- accrediting training programs that train to the skills standards and meet NIMS quality requirements;

- assisting states, schools, and companies to form partnerships for skills standards implementation, program certification, and credentialing of participants.

NIMS standards list the common duties and describe the knowledge, skills, and abilities needed to perform the duties well. The resulting skills standards define what industry wants workers to know and be able to do, and defines a skills and training framework for the metalworking industry nationwide. In many states metalworking training programs are rewriting their curricula to bring students up to the necessary levels to meet the skills standards, especially at Level I, which represents entry level job standards. NIMS standards are being introduced as benchmarks for high schools, community colleges, and vocational-technical schools in the following states: Arkansas, Connecticut, Illinois, Indiana, Kentucky, Massachusetts, Michigan, Minnesota, North Carolina, Ohio, Oregon, Pennsylvania, Tennessee, Virginia, and Wisconsin.

Appendix F of this study explains the NIMS standards in detail. Table 3 illustrates how the NIMS skills are clustered according to level and occupational specialty.

Capstone Opportunities	Business Owner, Journeyperson, Management, Engineering Technology, Sales and Application Engineering	
	Credentialing Process – Level 3	
Level 3 Additional competencies	Advanced Metal Forming	Advanced Machining
	Credentialing Process – Level 2	
Level 2 Focus topics	Stamping Operations Roll Forming Spinning Slide Forming Brake Press CNC Punch Press Laser Cutting	General Machining Screw Machining Die Making Mold Making Machine Building Maintenance and Repair
	Credentialing Process – Level 1	
Level 1 Basic skills	Metal Forming Skills	Machining Skills

Table 3: Overview of NIMS Levels

The two general categories of skills consist of machining and metal forming. Each category includes three skill level standards. Although the Level 1 standards are very broad and apply to many of the job specialties, Level 2 and 3 require increased specialization. Each level addresses similar skills with a graduated level of required precision, or with newer and more complex technologies. The credentialing process completes each level. Since the standards are entirely performance-based, individuals can advance at their own pace and be recognized for the skills they possess. The standards also provide employers with an objective assessment tool for worker performance and training needs.

Level I

Level I skills represent competencies reasonably expected of an individual with one year of experience in a good shop or apprenticeship program. These skills include basic competency with common machine tools and accessories, basic shop math and inspection techniques, and basic ability to proceed with further, more advanced training.

Level II

At Level II, more complex machining skills are introduced, along with Computer Numerical Control principles, angular measurements, and additional auxiliary equipment.

Level III

Level III, in general, addresses journeyman competencies. It includes proficiency with a wide range of machine tools, auxiliary equipment, task planning, and the ability to work with minimal supervision (NIMS, 1998).

Each of these three skill level groups is broken down into seven areas of occupational duties. Complementing the occupational duties are the academic skills and knowledge fundamentals upon which the occupational duties are based. Table 4 outlines the Level 1 NIMS machining standard. Each occupational duty is fully documented by NIMS and includes performance standards and assessment activities.

Occupational Duties	Knowledge, Skills, Abilities, and Other Characteristics
1. Job Planning and Management 1.1 Job Process Planning	**1. Written and Oral Communications** 1.1 Reading 1.2 Writing 1.3 Speaking 1.4 Listening
2. Job Execution 2.1 Manual Operations Bench work 2.2 Manual Operations Layout 2.3 Turning Operations-Between Centers Turning 2.4 Turning Operations-Chucking 2.5 Milling: Square Up a Block 2.6 Vertical Milling 2.7a Grinding Wheel Safety 2.7b Surface Grinding 2.8 Drill Press Operations 2.9 CNC Programming	**2. Mathematics** 2.1 Arithmetic 2.2 Applied Geometry 2.3 Applied Algebra 2.4 Applied Trigonometry 2.5 Applied Statistics
3. Quality Control and Inspection 3.1 Part Inspection 3.2 Process Control	**3. Decision Making and Problem Solving** 3.1 Applying Decision Rules 3.2 Basic Problem Solving
4. Process Adjustment and Control 4.1 Process Adjustment, Single Part Production 4.2 Participation in Process Improvement	**4. Group Skills and Personal Qualities** 4.1 Group Participation and Teamwork 4.2 Personal Qualities
5. General Maintenance 5.1 General Housekeeping and Maintenance 5.2 Preventive Maintenance 5.3 Tooling Maintenance	**5. Engineering Drawings and Sketches** 5.1 Standard Orthographic prints 5.2 GDT Orthographic prints 5.3 GDT Datum, Symbology and Tolerances
6. Industrial Safety and Environmental Protection 6.1 Machine Operations and Material	**6. Measurement** 6.1 Basic Measuring Instruments 6.2 Precision Measuring Instruments

Handling 6.2 Hazardous Materials Handling and Disposal	6.3 Surface Plate Instruments 6.4 Metric Conversion
7. Career Management and Employment Relations 7.1 Career Planning 7.2 Job Applications and Interviewing 7.3 Teamwork and Interpersonal Relations 7.4 Organizational Structures and Work Relations 7.5 Employment Relations	**7. Metalworking Theory** 7.1 Cutting Theory 7.2 Tooling 7.3 Material Properties 7.4 Machine Tools 7.5 Cutting Fluids and Coolants

Table 4: NIMS Occupational Duties and KSAO Characteristics

Relating the NIMS Standards to a Typical Manufacturing Job

To better understand how these skills standards are integrated into community college curricula, consider the following job description and how one of the occupational duties from the table above applies to that job.

> "The manufacturing technician works as a key member of the team of people responsible for the manufacture of products and systems within the overall structure of a manufacturing enterprise. The primary tasks of the team involve production planning and control, production operations management, quality management, manufacturing systems planning and management, and maintenance management. The technician, in general, assists and supports the professional members of the team. Particularly in some small to medium size enterprises, an experienced technician may be given responsibility for some aspects of manufacturing operations. While working primarily with the manufacturing operations team, there is continuing need for the technician to

interface with other professionals in the enterprise who have primary responsibility for product and system design, purchasing of materials, marketing and sales, and distribution." (NCE/AME, 2000, p. 12)

This job description requires a well-rounded individual with good soft skills as specified in item 4 under Knowledge, Skills, Abilities, and Other Characteristics (KSAO): Group Skills and Personal Qualities. However, specific technical skills are also required of this production technician. If this technician worked in a production-machining environment, vertical milling (occupational duty 2.6) would be a required skill. The NIMS documentation elaborates each duty with a detailed description of the performance standards, evaluation criteria, and required equipment and materials. Once the participant completes the learning activities – estimated to be 8 hours for this duty – a written milling exam is given. Finally, the participant is given a NIMS milling print and appropriate materials to machine the part. Exact specifications must be followed to pass the hands-on portion of the assessment successfully.

This specific occupational duty (2.6) focuses on milling. However, many other occupational duties and KSAO characteristics must be utilized. They would include under occupational duties:

- 1.1 Job Process Planning
- 2.2 Manual Operations Layout
- 6.1 Machine Operations and Material Handling (safety)

The KSAO characteristics required for this occupational duty would include:

- 2.1 Arithmetic

- 5.1 Standard orthographic prints
- 6.1 – 6.3 Measuring instruments
- 7.1-7.5 Metalworking theory

The NIMS standards are very specific in outcomes and assessment. However, NIMS has never been promoted as a complete curriculum. The program participant would learn about milling from a classroom lecture, videotape, textbook, demonstration, or hands-on practice. A variety of these learning tools can be used based on the facilities and instructional resources available.

A community college could use the NIMS skills standards to develop an innovative manufacturing program that ensured all of the occupational duties and KSAO characteristics are mastered. However, these skills standards must compete for attention in a community college curriculum already full of graduation requirements, academic fundamentals, and new technology. In the Delta College curriculum for example, several classes including Basic Mechanical Design, Intermediate Algebra, and Machining Processes could be examined to find out whether or not the NIMS topics were covered. Other courses such as Technical Communication or Professional Global Awareness could contain the soft skills specified in the NIMS standards. One problem with the traditional curriculum is that topics such as milling are "covered" in a Machining Processes class, but students might be hard pressed to perform a milling exercise to industry standards. Another difficulty is that when courses are taught in a variety of departments – mathematics, drafting, English - adherence to the NIMS guidelines may not be a priority.

The NIMS standards would more likely be reinforced in curricula currently being developed in the NCE/AME project. Because this associate degree program is built upon existing skills standards and constructivist learning theory, the participants would more likely be able to pass a competency assessment.

An Industry Perspective of NIMS

Metalworking companies also use skills standards to benchmark their training programs, credential their workers to demonstrate a quality workforce to customers, define pay-for-skill programs, and qualify for certification in comprehensive quality assurance programs. These companies recognize that the use of the skills standards, along with NIMS credentialing opportunities, provides a strong foundation for a workplace and school partnership to foster training for metalworking.

The NIMS web site (http://www.nims-skills.org) offers the following comments from those involved in establishing and maintaining these standards:

"Skill standards are invaluable to us because they are industry driven, competency based, and nationally validated. They enable us to clearly articulate our knowledge and performance expectations to employees, prospective employees, and educators."

Mike Bates, HR Director, Remmele Engineering, New Brighton, MN.

(Mike serves on the NIMS board of directors and is President-Elect.)

"The importance of the skill standards to our industry's future is clearly demonstrated when you consider that six otherwise competing trade associations came together in developing these metalworking standards."

Marvin Wortel, Chairman, Triton Industries, Inc., Chicago, IL.

(Marv has served as the first president of NIMS.)

"Once NIMS programs are instituted nationwide, it will be a pretty simple matter to know what potential employees actually know and can do, and to have an opportunity to offer existing employees to upgrade and certify their skills."

Frank York, President, Newman Machine Company, Greensboro, NC.

(Frank has been instrumental in starting a partnership of schools, public training programs, and a technical center to implement the skill standards and credentialing activities to help employers in Greensboro.)

Equally important, the NIMS standards detail the progression of skills and abilities needed from entry-level positions to higher positions in engineering technology, management, or technical sales. NIMS standards dispel the "dead end" career path of manufacturing related jobs. The NIMS standards provide both depth and breadth to curricular topics. In terms of breadth, the standards specify all of the technical and non-technical competencies required of an employee in a modern manufacturing environment. The depth of a topic refers to an assessment that closely resembles a job performance standard. This depth requirement challenges the courses when participants are briefly introduced to topics instead of demonstrating a thorough understanding of them. Community colleges can use the NIMS standards to evaluate their existing curriculum, or they can proceed with actual certification of their facilities, instructors, and students.

One problem with incorporating workplace skills in college curricula is that the adaptation is often done haphazardly in various course offerings. The NIMS metalworking skills cover many academic and vocational competencies, and must be integrated into a whole program or set of courses. For example, in a community college the individual competencies may be assigned to the various classes that comprise a degree, apprenticeship, or certificate. These classes could include English, mathematics, metallurgy, mechanical drawing, or machine shop. Unless all of the instructors understand the competencies and are willing to evaluate the students in these areas, the assessment of measurable objectives cannot be achieved. Each instructor could check off the applicable competencies without changing how the material is presented or tested.

Another difficulty arises in trying to grade or evaluate the mastery of many of the "soft skills" important for technical workers today. Employers emphatically support the need for employees to acquire oral and written communication skills, work in teams, apply problem-solving techniques, and recognize appropriate moral conduct (Bailey and Merritt, 1995; Parry, 1996). These skills do not easily fit the traditional curriculum and are difficult to assess. General support for skills standards achievement is strong, but consensus breaks down when specific tests and controls are placed on the measurement of these skills in our students (Perelman, 1992).

The role of professional societies and accreditation institutions in curriculum reform

Many programs in higher education are influenced by the standards and guidelines of external accreditation agencies. These agencies seek to influence institutional effectiveness and program integrity. Accreditation is the process by which a program or institution is recognized as being in conformity with some agreed-upon standard (Anderson and Associates, 1975). First and foremost, a college is accredited as an entire institution. Although institutional accreditation is not mandatory, most colleges seek accreditation to improve institutional status and to qualify for certain funding sources. The United States Department of Education monitors the six regional non-governmental accrediting agencies. The North Central Association of Schools and Colleges is the accrediting agency for Michigan and many other Midwest states. Once the institution is accredited, individual programs may seek additional accreditation (ABET, 2003).

As stated earlier, one of the functions of NIMS is to accredit manufacturing program facilities. NIMS establishes clear expectations for safety, organization, and equipment utilization in manufacturing laboratories. NIMS will accredit a training program at the secondary or post-secondary level. Training programs run by private companies or trade associations are also eligible for accreditation. Instructors are credentialed independently from the program. A series of competency assessments involving written tests and shop performance exercises are given to instructors, allowing them to document the three levels of achievement. Certified instructors are necessary for program accreditation. The

NIMS organization also certifies program participants as they pass through the credentialing process of the three skill levels. Michigan currently has eight NIMS accredited programs, including two in community colleges.

The US Department of Education recognizes dozens of program accreditation agencies. The Accreditation Board for Engineering and Technology (ABET) is recognized nationally as a powerful accreditation agency for college computer and engineering programs. Although NIMS accreditation consists largely of checklists to make sure that all proper program procedures and components are in place, ABET takes a broader look at a program and considers the quality of the individual components. During site visits the accreditation team attempts to evaluate items such as intellectual atmosphere, faculty and student morale, and the stability of the program. The two primary purposes of ABET are to: "Organize and carry out a comprehensive process of accreditation of pertinent programs leading to degrees, and assist academic institutions in planning their educational program", and "Promote the intellectual development of those interested in engineering, technology, computing, and applied science professions, and provide technical assistance to agencies having professional regulatory authority applicable to accreditation" (ABET, 2003, p.1).

ABET specifies that the programs, not the institution or department, become accredited. Further, when alternative routes exist to completion of the program, such as off campus classes or distance learning alternatives, all routes must be accredited. One interesting detail of ABET accreditation is the specific name of the program. Words such as "engineering" and "technology" must carefully appear as specified to meet strict guidelines. ABET programs ending with the term "technology" are "in the broad area of technical education between engineering and vocational education / industrial technology" (ABET, 2003, p.3). ABET separates the requirements for a "Manufacturing Engineering" program from a "Manufacturing Engineering Technology" program. This agency looks at faculty, math and science requirements, facility use, and specialization topics to determine the appropriate designation of accreditation. Community colleges can be accredited at the engineering technology associate degree level. Delta College is currently the only Michigan community college with the ABET accreditation. The Delta College catalog description of the Mechanical Engineering Technology program explains to potential students that the accredited program "expands your marketability nationally as an engineering technician" (www.delta.edu/degreesprograms/MechanicalEngineer.asp). This type of accreditation can be a major selling point, especially if the school itself does not have a national reputation. Although it would be possible to achieve NIMS and ABET accreditation for the same program, NIMS is better suited to a program that trains apprentices and manufacturing technicians. ABET accreditation is geared towards programs that emphasize transfer to a baccalaureate degree.

ABET supplies a set of general criteria applied to all programs. These criteria include: program educational objectives, program outcomes, assessment and evaluation, program characteristics, faculty, facilities, institutional and external support, and general program criteria (ABET, 2003). In addition to general criteria, the Technology Accreditation Commission (TAC) of ABET also supplies specific program criteria for each of about 20 technology programs. These include program titles such as Industrial Engineering Technology or Manufacturing Engineering Technology.

The general direction of ABET in the past decade has been to relax the rigid requirements covering detailed lists of competencies, recognizing the diversity that may exist between programs. Individual programs must still demonstrate the achievement of goals and objectives. Felder and Brent (2003) argue that properly implemented, "the intense nationwide curricular revamping ... could lead to dramatic changes in engineering education" (p.7). They go on to warn that faculty members could simply write the ABET program objectives to fit existing courses, reducing the likelihood of a program with common objectives meant to unify the curriculum. In the past, ABET accreditation could be carried out primarily by one person responsible for coordinating all of the paper work, a self-study report, and presentations. Felder and Brent explain that under the new guidelines "all faculty members involved in teaching required courses must now understand and be involved in the accreditation process on a continuing basis".

Several of the professional societies also sponsor certification programs that emphasize educational outcomes in higher education. These organizations include the American Society for Quality (ASQ), the Society of Automotive Engineers (SAE), and the Institute of Industrial Engineers (IIE). The Society of Manufacturing Engineers (SME) is involved in manufacturing education and offers several levels of certification. These levels include Certified Manufacturing Technologist, Certified Manufacturing Engineer, Certified Engineering Manager, and Certified Enterprise Integrator (SME, 2004). This certification is geared towards the individual, not the school. The guidelines for certification are often used in higher education to prepare students for this certification exam.

Teresa Hall (2002) argues that the SME certification exams are an excellent assessment tool for curriculum evaluation. These exams reflect the skills standards of the manufacturing industry, and the exam is independently proctored and graded. The exam outcome is highly reflective of program effectiveness. She goes on to explain that the detailed exam reports provide descriptive statistics of the results, including a breakdown by knowledge sector. When a large percentage of graduates take this exam, the composite results provide an excellent perspective of curriculum effectiveness.

Although the SME certification does not certify facilities or programs, it helps build faculty credentials. It also fits into the broader scope of ABET program certification. ABET expects that the curriculum reflects the current industry skills standards, and makes use of multiple assessment tools to ensure effectiveness. Certification exams used by professional societies help meet this requirement. Anderson and Associates (1975) give two assumptions for the assessment of instructional programs that lead towards certification. First, the best predictor of job performance is performance on similar tasks. Second, evaluation and instructional programs should be comparable in their objectives and techniques. Course content, testing methods, and actual workplace expectations should be properly linked.

In summary, external support exists for curriculum reform in technology related post-secondary education. Accreditation agencies, professional societies, and skills standards organizations have established guidelines and expectations for program improvement. Faculty and administration can now choose between meeting the minimum requirements of these guidelines or engaging in a complete transformation in curricular design and assessment.

A proposed model of curriculum reform

This study will focus on curriculum reform in the Michigan community college manufacturing programs. To develop a model of curriculum reform, I first compared two existing models of program accreditation and merged them into a single model. Next, I compare this merged program model to the Stark and Lattuca (1996) curriculum model. Finally, I describe a model of curriculum reform that will help frame the curricular discussions in this study.

Comparison of the NIMS and ABET Guidelines

The ABET accreditation guide (ABET/TAC, 2003, p. 5) provides a useful overview of important program criteria. These criteria are used by ABET to systematically evaluate the various components of a technology program. The NIMS accreditation guidelines (NIMS, 1998) list similar criteria except that the components are spelled out in a more precise form. Table 5 shows a comparison of the accreditation criteria.

ABET	NIMS
Program Educational Objectives: broad statements describing career and professional goals	NIMS skills standards reflected in the program objectives
Program Outcomes: specific units of knowledge and skills expected from the students	Trainees must be aware of NIMS performance requirements and select appropriate content areas
Assessment and Evaluation: includes portfolios, standardized exams, projects, and surveys of student performance in the workplace	Evidence of active credentialing program. Use of NIMS assessment tools – written tests and performance tests
Program Characteristics: this includes the curriculum and the division of the major content areas	NIMS skills standards incorporated into the curriculum
Faculty: educational and career background, scholarly activities, professional development	Instructors must be NIMS certified in the topics they teach
Facilities: suitable classrooms and labs, technology infrastructure, student support services	Facility must meet OSHA requirements. Labs must be equipped to support the topic areas that are taught
Institutional and External Support: administrative support, adequate funding, active program advisement committee	Program must have support of administration. Advisory committee is actively involved in accreditation process.
Program Criteria: inclusion of technical specialties implied in the program title	Appropriate levels of certification to match the student and facility capacity

Table 5: Comparison of ABET and NIMS Criteria

Note that the categories are similar across the two agencies. NIMS, however, more narrowly defines the criteria for each category. These program models could represent the two extremes of community college manufacturing programs. The ABET model represents an academic focus with an emphasis on transferring into a 4-year program. The NIMS program criteria contain a more vocational focus with an emphasis on job skills and career preparation. A typical community college manufacturing program would generally fall somewhere between these two types of guidelines.

The ABET documentation carefully explains the terminology used in the list of program criteria, acknowledging that different institutions use different terminology. Educational objectives are defined as "broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve" (ABET/TAC, 2003, p. 5). Educational outcomes are "statements that describe what units of knowledge or skill students are expected to acquire from the program" (p. 5). ABET further requires that these objectives and outcomes are determined through a "documented process" that includes the "needs of constituents" (p. 5). In other words, the program must reflect the current trends in industry and the requirements of relevant transfer institutions for the program participants. One of the key components of the NIMS curriculum is that the process of defining objectives and outcomes has been completed.

There is no reason for a college to have to "start from scratch" when implementing the NIMS standards. Grubb and Associates (1999) explain that many external standards exist that help define an academic program. Among the less effective standards are those that affect the "academic transfer" of a course. Transfer requirements can vary between institutions and do not often relate to vocational skills. According to Grubb and Associates external standards in occupational programs relating to successful employment are among the most effective standards. Felder and Brent (2003) note that earlier versions of ABET accreditation criteria were "rigidly prescriptive" and were too detailed. The new ABET standards are now described by some as too "flexible" and "fuzzy", as much more latitude is given in the coverage of specific material. The new criteria place more emphasis on the process used to develop the objectives and outcomes. The NIMS program outcomes are very specific. However an institution can select the specific NIMS topic areas to be included in the program. The NIMS standards are modular. For example, Level 1 of the machining standards includes eight topics – not all of which need to be included in any given program.

Assessment and evaluation are included in both sets of criteria. Again, the NIMS assessment procedures are very well elaborated. Standard written exams are prepared for each topic and lab performance based projects have been fully developed and tested for each set of competencies. Specific criteria exist for successful completion and remedial activities are specified. The ABET criteria include these two types of assessments along with portfolios and data relating to successful student placement after graduation. ABET also places value on using industry standard exams such as the SME certification exams. Tillman (2002) claims that this type of exam can be used to rate program effectiveness when a large number of program completers take the exam. Felder and Brent (2003) posit "assessment drives learning (p. 14)", explaining that if students know they will be held accountable to a certain standard they will apply themselves accordingly.

ABET considers faculty a key component of a program, certifying the credentials of the faculty as well as the intellectual atmosphere, stability, and morale of the faculty (ABET, 2003, p. 6). ABET looks for a consistent balance between faculty professional practice, scholarly activities, and teaching effectiveness. The number of faculty must be sufficient to support all necessary program activities. Most importantly, a full-time faculty leader should be assigned to each program to ensure continued guidance to the program. ABET also requires notification when "significant changes" in the faculty occur during an accreditation period. In the NIMS accrediting procedures, the primary faculty focus is the instructors' certification in the specific content areas. However, the great amount of organization and preparation needed for NIMS accreditation would also require many of the same faculty characteristics as ABET. Grubb and Associates (1999) explain the importance of the faculty in assuring that the program outcomes and objectives are actually carried out in the classroom.

ABET places the topic of curriculum under Program Characteristics. Specific directions are given for academic program requirements such as number of credits required and main grouping of courses. ABET recommends that technical program content comprise between 1/3 and 2/3 of the total credits. Because the design of the NIMS standards also allows for integration into a high school career center or private training organization, no specific academic standards are mentioned. NIMS does provide much documentation for the skills standards, providing enough material for detailed course outlines and student activities for each topic. Both NIMS and ABET leave room for innovative curricular activity that engages students and produces documented results.

Grubb and Associates (1999) explain that when a program is developed without careful consideration of the student, expectations for student performance may be unrealistic. In the community college programs special attention must be placed on tracking students into an appropriate level class. NIMS requires that students are well informed of the various components of the skills standards and the progressive nature of the 3 levels. Modules at the entry levels are provided to ensure that the participants can achieve early success. Active credentialing of students is one of the primary concerns of NIMS. ABET accreditation also involves a qualitative sampling of student work. Assignments, tests, laboratory projects, and other appropriate student work samples demonstrate mastery of technical subjects. Compliance with oral and written communication skills is also evaluated by examining student work. Additionally, ABET is interested in standardized test scores and student transfer or employment records after leaving the program. Finally, ABET looks for student support services designed to help students succeed in the program.

Institutional and external support are treated as one topic by the ABET criteria and separate topics under NIMS. Each agency considers administrative support vital to the program. ABET defines institutional support in faculty selection and supervision, student services, facility assignment, and public relations. Perin (2000) describes institutional support as bringing together key players from across the college to collaborate on program improvement.

Administrative support also comes from providing adequate program facilities, program funding, and assistance in curriculum development. External support is defined by ABET as a program advisory committee that "periodically reviews the program curricula and provides advisement on current and future needs of the technical fields in which graduates are employed" (ABET/TAC, 2003, p. 8). Program advisory boards are considered a key component of occupational program vitality (Jacobs, 2001; Thompson, 1994; Salzman, 1998). NIMS accreditation criteria regarding both administrative support and advisory committee involvement are very similar to ABET.

Facilities are considered another important element of a successful program. This topic is mentioned as part of institutional support and also as a separate item. ABET emphasizes academic support systems such as classrooms, computer and technology infrastructure, and student information resources. Laboratories and equipment should also reflect current industry standards. One of NIMS primary concerns is that the laboratories meet the current Occupational Safety and Health Association (OSHA) standards. Laboratories for NIMS programs must have updated and well-maintained equipment to allow participants to successfully pass the shop performance tests.

Comparing the NIMS / ABET Program Guidelines to a Curricular Model

This composite program model from NIMS and ABET provides a useful framework for studying the community college manufacturing programs. It also becomes necessary to elaborate the curriculum component of this model. Stark and Lattuca (1996) propose this curricular model: purpose, content, sequence, learners, instructional processes, instructional resources, evaluation, and adjustment. Table 6 shows how the composite program model and the curriculum model relate.

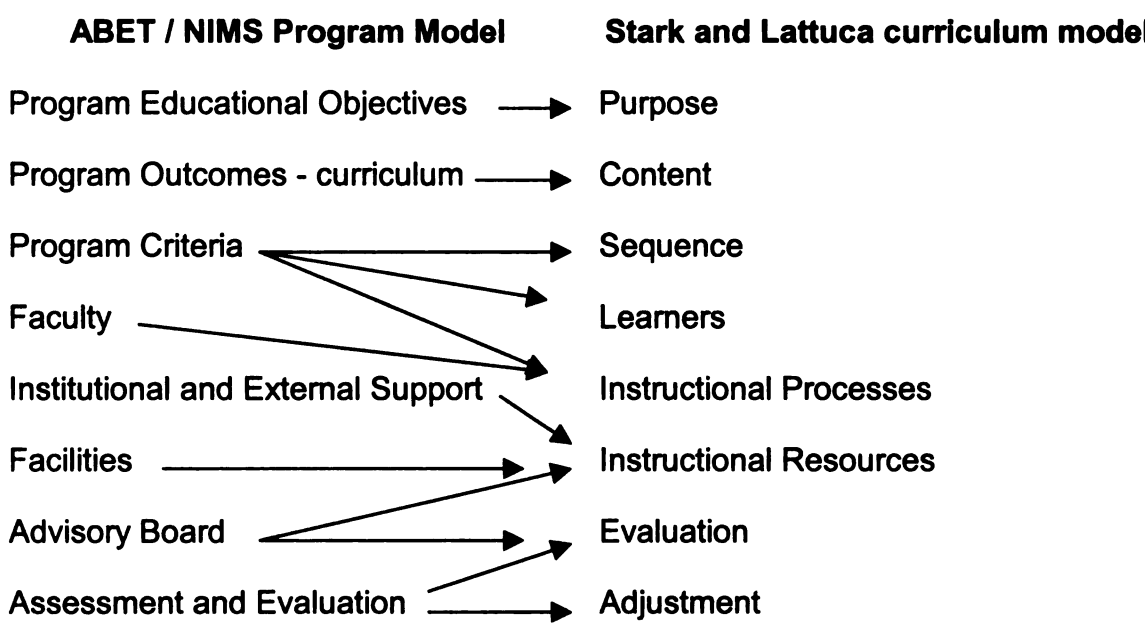

Table 6: Comparison of NIMS/ABET and Stark and Lattuca Models

Stark and Lattuca explain that the first component of the academic plan – the purpose – is likely to generate lively discussion. They document a wide variety of responses from college faculty on the purpose of the college curriculum. Specific areas include knowledge, skills, and attitudes to be learned. Many studies show that community college faculty continue to be divided over the topic of curricular purpose (Stiehl and Lewchuk, 2002; Brewer, 2000; Perin, 2000). In the case of NIMS and ABET, the groundwork has been laid for specifying the outcomes to the programs. The ABET outcomes are general in nature while the NIMS outcomes are quite specific.

Curricular content can also create tension between academic and vocational subject matter, and between external standards that lean toward either transfer criteria or occupational goals. Once the academic plan has been agreed upon, the content should be linked to that purpose. Again, external standards or accrediting agencies can help supply much of the course content.

Stark and Lattuca present alternative methods of determining the sequence of curricular content. The content could be presented chronologically, thematically, or grouped into integrated activities. Perin (2000) promotes the advantages of integrated courses in community colleges where occupational and academic course content are taught in a combined fashion. She makes a strong pedagogical case for this type of teaching but admits that good examples of integrated instruction were hard to find in community colleges. Many structural issues seem to discourage this type of cooperation between academic and occupational instructors. Kelley and Weston (1996) promote the capstone course as a method of synthesizing a series of related courses. NIMS compartmentalizes content into three distinct levels, each requiring a synthesis of both general knowledge such as mathematics and blueprint reading along with specific skills such as machining or quality control activities.

Stark and Lattuca warn that all curricular activities must realistically be geared towards student ability. This step is especially important at the community college level where open admission policies can play havoc with faculty expectations for student performance. Studies on academic preparation and remediation in the community college reveal general agreement on the nature of the problem but little consensus on how to address it. Some community colleges have kept dual academic and vocational tracks (Bailey and Averianova, 1999). ABET looks for a comprehensive student support service to assist students in achieving their goals. A study conducted by Brewer (2000) concluded, "a significant minority of faculty feel more emphasis should be given to basic skills, perhaps reflecting a frustration with the inadequate skill levels of students who enroll in community colleges" (p. 5). Grubb and Associates (1999) remind us of the "blissful indifference" of the community college instructor teaching advanced level material to under-prepared students.

Much discussion is taking place in community colleges about instructional processes. Although the "lecture" has been identified as one of the least effective teaching approaches, the economy and simplicity of the lecture leads Stark and Lattuca to acknowledge that this is still popular in college classrooms. They also mention other methods of instruction such as self-paced, collaborative, and technology based delivery formats. Most important is that instructors try to employ a variety of instructional delivery with solid pedagogical reasons for doing so. The NIMS documentation is strangely silent on the topic of content delivery method. ABET encourages the use of a variety of instructional delivery formats but does not specify them. Grubb and Associates note that community colleges have a reputation for solid hands-on instruction with both the instructors and students favoring that type of educational experience.

As the demand for modern manufacturing technology in the curriculum increases many new instructional materials have become available. Stark and Lattuca comment that a college course has traditionally been built around the content and sequence of the textbook selected for that class. When a class is based on a set of external standards it may be beneficial to choose from videos, computer mediated materials, Internet resources, and pre-packaged curriculum components. Laboratory facilities also fall under this topic of instructional resources for hands-on learning opportunities. Jacobs (2001) suggests even using manufacturer specific training modules, increasing the likelihood of practical learning activities that closely relate to the workplace. Except for well-funded curriculum efforts such as the NCE/AIM project, it appears that instructors no longer have the time or the resources to develop technology related courses from scratch. The Michigan EDJT curriculum project (http://www.mistcurriculum.org) is another good example of how government can fund a curriculum project, freely disseminating the materials to all the community colleges in the state. The Internet has largely been responsible for eliminating the duplication and distribution costs of course materials, expanding the low cost /no cost options of instructional materials.

The evaluation and adjustment components of the Stark and Lattuca program plan are similar to the process manufacturers use in evaluating their own programs and processes. The first common theme in manufacturing process control is that "if you can't measure it, you can't improve it". Stark and Lattuca emphasize that specific measurable goals of the instructor and the student must be at the forefront of evaluation. Once the evaluation plan is completed, adjustment of the curriculum closes the loop back to the planning stages of the curriculum. This process creates a circular pattern of continuous program improvement, similar to what manufacturers need to accomplish to remain competitive. The concepts of measurable program outcomes and performance measures fit closely with the National Skills Standards Board (2000) goal stating, "Educators can use skill standards to create curriculum that better prepares students for work" (p. 2).

A Curriculum Model to Guide this Study

These blended models of ABET and NIMS program criteria, enhanced with the Stark and Lattuca (1996) curricular elements, provide a model useful for evaluating curriculum in the community college manufacturing programs. In Figure 2 I attempt to define a model of curriculum reform to guide the survey and case study issues addressed in the scope of this study.

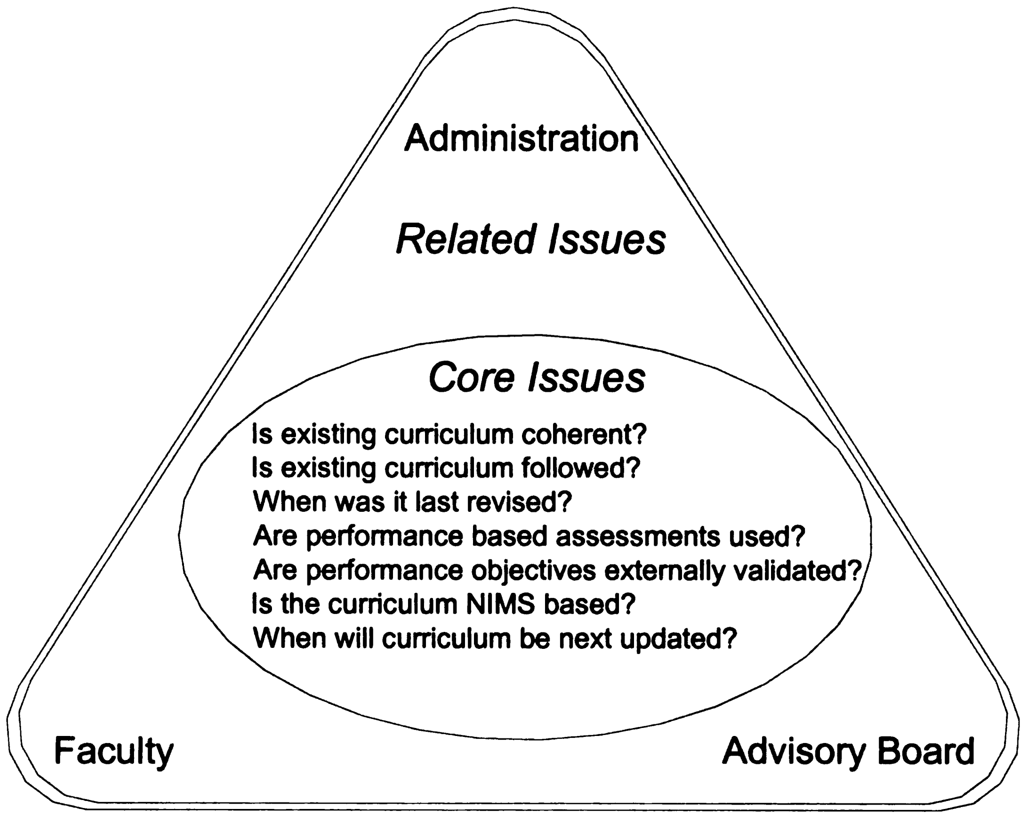

Figure 2: Curriculum Reform Model

The core issues of curriculum reform identified in this model are the focus of the survey. These issues address the research questions of this study. The related issues in this model are taken from the general program criteria spelled out by ABET and NIMS. These three related components include faculty, administration, and advisory committee.

This study began by identifying the viable manufacturing programs in Michigan community colleges. Second, the instructors associated with these programs were surveyed. The questionnaire was sent to the individual instructors directly responsible for the curriculum development in their own programs and addressed the core issues identified by the curricular model in Figure 2. Finally, the site visits conducted after the survey addressed the related topics identified in this model.

Chapter 3 of this study further discusses the relevance of the core issues addressed in this model and builds a conceptual framework upon the working model developed in this chapter.

Chapter 3

METHODOLOGY

Conceptual framework

This study on manufacturing curriculum in Michigan community colleges investigates the influence of NIMS Metalworking Skills Standards on the curriculum. Other factors affecting curriculum reform in this environment are also investigated. The NIMS standards clearly identify career paths, skill levels, and occupational duties. Special emphasis is placed on performance standards and skills assessment. The NIMS documentation does not propose a specific curricular model. Both NIMS and ABET allow curricular diversity and program flexibility, recognizing that programs can reflect local employment requirements or specialized topics. A variety of instructional designs can utilize the NIMS standards for program content and assessment.

This conceptual framework identifies the critical components of the manufacturing curriculum considered in this study. The primary focus of this study will be the *formal* curriculum in the community college manufacturing programs – referring to the manufacturing curriculum officially agreed upon, formally approved, and published in the college catalog.

The NIMS metalworking skills standards cover two basic occupational categories: machining and metal forming. A core group of general educational requirements and basic workplace competencies form the foundational base for both of these areas. Building upon the core skills, NIMS details all of the topics to be covered in each of the occupational categories. Although virtually all of the Michigan community colleges teach some of these basic skills – shop math, blueprint reading, communication skills – this study will focus on colleges offering an associate degree in machining or metal-forming.

One important item to be studied is the breadth of the manufacturing curriculum. Contrary to those who believe the NIMS standards are primarily shop competencies, the NIMS standards suggest a comprehensive curriculum. General topics include written and oral communication skills, math, problem-solving skills, group and teamwork dynamics, and other general education topics. Diamond (1998) explains that the scope of the curriculum can range from a course or program to the entire institution. Simply examining a few manufacturing related courses would not reveal the entire curriculum and its alignment with the complete spectrum of NIMS topics. Like NIMS, the National Skills Standards Board (2000) guidelines propose the teaching of critical core competencies that support a variety of industrial occupations. Built upon this common foundation are the specific skills that focus on individual job classifications.

Comprehensive in scope, the NIMS standards remain focused on specific outcomes. For example, simply learning *about* oral and written communication does not satisfy the NIMS outcome of applying those skills in communicating an actual job process plan. Similarly, taking a general college math class does not ensure the learner's ability to apply trigonometry to a technical blueprint. Completing an introductory computer course does not guarantee that the learner can use a computer in an industrial setting. Perin's (2000) study of integrated curriculum in community college programs found that well integrated academic and occupational courses were more the exception than the rule. Controlling the specific delivery of these competencies represents a difficult task for manufacturing curriculum reformers as many core skills are taught in other programs or departments. Linkages to these competencies must be evident in the manufacturing curriculum. An additional burden is placed on the manufacturing departments to verify that the learners can apply general education skills to specific occupational activities.

The outcomes and assessment components of the curriculum are critical to the NIMS model. Stiehl and Lewchuck (2002) propose the *outcomes framework* as a method of articulating the authentic tasks and projects a learner should be able to accomplish. This constructivist framework suggests that simple written tests may not provide proof that educational outcomes are achieved. Jacobs (2001) questions the practice of using assessments designed only by faculty members. The NIMS standards include assessments developed and validated by industry representatives. Evidence of genuine assessment activities will help to verify program compliance to NIMS standards.

Core Issues

A study of this nature cannot examine in detail the manufacturing curriculum of all 28 Michigan community colleges. The core issues identified in Figure 2 at the end of Chapter 2 are used to help frame the curricular discussion in this study. The questions utilized in the survey help summarize the current state of curriculum reform, and whether or not the programs in this study have been directly influenced by NIMS. The five core issues in the survey are elaborated below:

Coherent curriculum. In some schools, the curriculum is highly developed and easily accessible to faculty, students, and administration. It is generally agreed upon and followed by all faculty members. In other schools the formal curriculum may be an obscure document that gets dusted off every five years or so when a question comes up. For the NIMS standards to drive the manufacturing curriculum a high level of support for structured curriculum must exist. Diamond (1998) states, "For some faculty members any approach that requires defining and measuring learning outcomes or structuring a curriculum is perceived as infringing on their rights" (p. 58). Some instructors may resist any formal curriculum reform that regulates and guides the way they teach their classes. Programs with a highly structured curriculum, including outcomes based performance measures, may be more likely to embrace skills standards based programs. The simple transaction involved in requesting a copy of the official manufacturing curriculum could indicate the level of curriculum development within a given department.

Frequency of curriculum revision. One factor influencing curriculum reform in a manufacturing program is the introduction of new technology into the manufacturing process (Wells, 1996). Consider the following example of technological change in machining over the past several decades. In the 1970's, computer numerical control (CNC) machining was established as a new manufacturing discipline. New degrees were offered and exciting careers were built on this modern technology. In the 1980's, CNC machining became a specialty area within tooling and machining programs. During the 1990's, CNC technology had become the new paradigm for the machining trades. Major curriculum reform at least every ten years became necessary to keep programs current with these changes in industry. NIMS has committed to revising the skills standards on a regular basis to reflect the adoption of new technology into the manufacturing process. This frequency indicator helps define how much time and attention is given to curricular reform issues. If the curriculum has not been updated in the past five years, NIMS skills are probably not reflected in the current program.

Performance based student objectives. In addition to the general scope of the manufacturing curriculum, specific courses must be analyzed to determine whether or not the corresponding NIMS skills standards are addressed. One of the many criticisms of employers is that students learn "about" the course content without being able to perform tasks expected of them in the workplace (Stiehl and Lewchuk, 2002). An example would be using a true / false test to determine whether or not the student can operate an engine lathe. In an introductory machining class the skills listed as occupational duties for NIMS Level 1 machining should be clearly identified in the course outline. Assessments should also closely resemble the NIMS written tests and laboratory performance demonstrations.

Externally validated performance measures. Virtually all accrediting agencies and curriculum reform guidelines recommend that externally validated skill sets be used in the reform of curricula (ABET, 2003; SME, 2004; Grubb and Associates, 1999). This criterion requires student assessments, projects, and portfolio work based on documented industry standards and expectations. Jacobs (2001, p. 188) explains this concept: "In brief, vocational education as a discipline is continually challenged to sort and resort its subject matter based on an external standard: mastering these skills will lead to a job. It is not timeless knowledge, but linked to specific process and technological change."

Use of the NIMS skills standards. One of the questions asked in this study is whether or not the NIMS standards have had a noticeable effect on Michigan community college manufacturing curricula. Proper integration of the NIMS standards would assure that the curriculum meets all of the guidelines of externally validated performance measures. However, by adhering to many of the good standards of curriculum development existing prior to NIMS it would be possible for a program to meet the general NIMS standards solely because it was properly designed and implemented with cooperation from local industry.

Inclusion of national skills standards does not rule out addressing skills unique to local manufacturing companies. In some cases, evidence of curricular diversity indicates the ability of a community college to respond to the local needs of manufacturers. Faulkner (2002) explains that national skills standards provide universal core competencies and specific job related skills, whereas community college curricula must still meet the needs of local constituents.

Grubb (1999) notes that in the sub-baccalaureate labor market both employers and job seekers primarily search within the local community.

Related Issues

Advisory boards, faculties, and administration also can affect curriculum reform. The advisory board is mandated by both ABET and NIMS as a primary program component. One of the goals of the NIMS metalworking standards is to strengthen the relationship between educators and the manufacturing community. The program advisory board is the primary interface between the educational community and the workplace (Bailey and Merritt, 1995). The National Skills Standards Board recommends voluntary partnerships between "employers, employees, unions, educators, and community organizations (NSSB, 2000, p. 4). In answering the question of why or why not NIMS standards have influenced the curriculum, I consider the level of external support for the standards. If advisory boards and local industry councils place a priority on NIMS standards, I expect to see movement towards curriculum revision. In regions where little external support for NIMS exists, the local community colleges might not be convinced that the NIMS standards must be reflected in the manufacturing curriculum. Along with approving the curriculum, advisory boards can be beneficial to the program by providing long-term support and resources for the program.

In addition to external support for a manufacturing program, internal institutional support is also needed to ensure adequate resources for the program to meet NIMS or ABET standards. Jacobs (2001, p. 191) calls for "maintaining administrative and faculty curriculum currency", and the required time and resources to do so. One indication of internal support for a comprehensive manufacturing program is an administration and a board of trustees that value and encourage a strong manufacturing curriculum. Stark and Lattuca (1996) stress that administrators have both the power and responsibility to create an environment where curriculum development is encouraged and promoted. ABET looks for sufficient financial and facility resources to support a healthy program. NIMS offers program guidelines for manufacturing facilities. NIMS also offers the service of facility certification. Equally important will be the level at which administrators become involved in the curriculum revision process. Diamond (1998) explains that instructors tend to focus on specific courses and often lose sight of the scope of the curriculum. Department heads and deans will bring a broader perspective to curricular issues. Administrators are more likely to attend regional meetings where program information is shared between schools and with industry representatives. Because the issue of NIMS curriculum revision will likely need to be addressed by an entire faculty group or department, coordination of activities by an administrator will be necessary. Administrative support is needed to get the curriculum revision process underway, as is perseverance to push the revisions through the formal channels (Bailey and Badway, 2002).

Community college faculty members remain at the center of curricular revision activities (Bailey and Badway, 2002). Regardless of external forces driving curriculum reform, Ratcliff (1997) comments on the tendency of faculty to tweak the curriculum continuously: "Actually, changing the curriculum is easy. The faculty does it every term in thousands of courses" (p. 5). He goes on to explain that by adding experimental courses, seminars, and modifying existing course content, the actual curriculum is always in flux. Periodically, the formal curriculum is revised to reflect what is actually happening in the classroom. This becomes the *descriptive* model of curriculum reform, versus the *prescriptive* model. The case studies also address the amount of faculty time and resources allocated to curriculum issues. If community college instructors spend 90% of their time on teaching and classroom related issues (Lombardi, 1992) curriculum revision would remain a slow and painful process. Even when instructors are allowed release time or compensation for curricular activities, other forms of support may be necessary. This support could take on the form of faculty training, networking with other colleges on curricular issues, or assistance from instructional designers who can move quickly from concept to finished product.

These three components – administration, faculty, and advisory board – directly influence the curriculum and influence each other. Similar to the checks and balances found in American government, these three entities must remain in proper balance to encourage an atmosphere conducive to curricular reform. Figure 3 shows the relationships between these components.

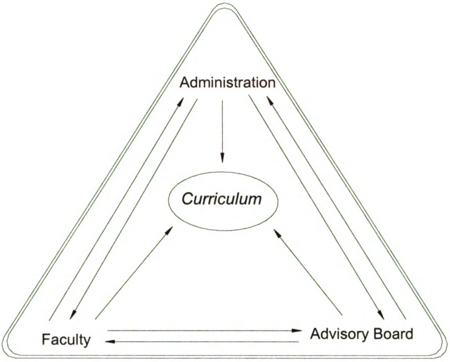

Figure 3: Three Factors Affecting Curriculum

In community colleges the administration affects the faculty members in several different ways. First, the administration must create job descriptions, hire faculty, and supervise faculty work. Second, the administration is responsible for coordinating projects such as curriculum reform where multiple faculty members or departments must work together (Stark and Latucca, 1996). Finally, and most importantly, the administration has the power to influence faculty workload and control resources allocated to faculty for curricular reform projects. Grubb and Associates (1999) found that while good pedagogical practice can exist in almost any type of environment, it is more likely to occur where the administration values and encourages good teaching practice. The administration can also have a direct influence on the effectiveness of the advisory board. The higher status of administrators can help in recruiting key advisory board members and maintaining healthy working relationships with local companies. Equally important is for the administration to orchestrate advisory board meetings and generate meaningful methods of showing appreciation for the work of the advisory board. One difficult task of the administration is to mediate the immediate needs of businesses with the long-term academic goals of the faculty.

The advisory board can influence college administrators by providing an accurate assessment of industry trends and how the school needs to respond. Bailey and Averianova (1999) mention that political support is another important component of industry involvement in education. The advisory board can also provide faculty with instructional resources including plant tours and realistic examples of student projects. Jacobs (2001) suggests that employers could help educators implement vendor-specific training programs that would add meaningful curricular content.

The faculty, although primarily focused on student learning, must look for ways of keeping busy administrators informed of new program challenges and changing needs in industry. Stark and Latucca (1996) state "faculty and administrators share responsibility for curriculum administration" (p. 310). They explain that faculty may wish to carry out curricular tasks without interference, which could lead to "uncoordinated programs that may serve isolated interests and fail to achieve either the college's goals or students' goals". Waiting for administrators to take notice of falling enrollment or distressed programs may leave faculty members with few options for improving the program. The faculty must also take the initiative to communicate with advisory board members and update them on curricular activities.

Other Factors

This conceptual model began with identifying the core issues of a NIMS based manufacturing program. Recognizing that curriculum reform occurs as a result of several combined forces, the second portion of the conceptual framework identifies other related issues. Finally, this study also addresses the question of why NIMS has or has not influenced the curriculum. To better understand the presence of the NIMS curricular components in a manufacturing program, several other factors influencing the curriculum revision and reform process are considered. The NIMS standards are not in themselves a call for widespread curriculum reform. A comprehensive manufacturing program could already contain many of the critical NIMS components. When a manufacturing program is faced with curriculum revision, the NIMS standards may provide a framework for curricular content and the corresponding assessment techniques.

Program funding remains a priority in occupational programs requiring expensive laboratory facilities. Educational administrators must constantly survey the horizon to anticipate changes in program funding guidelines. Grant money targeting certain types of program development becomes a source of additional revenue. The state of Michigan already has provided 1.6 million dollars in grant money for community colleges to develop outcome-based manufacturing curriculum using external industry standards (http://medc.michigan.org/news/edjt). If the state decides to tie additional program funding to NIMS based occupational programs, curriculum reform will shift into high gear in many colleges currently considering future changes.

Institutional stress and declining program enrollments can also become a driving force for curriculum reform. Bailey and Merritt (1995) see skills standards as a promotion of industry partnerships and community support. Jacobs (2001) notes that when a decline in enrollment occurs in programs where the job market remains strong, the programs may have become outdated or unable to keep up with industry requirements. NIMS skill standards may be seen as a way to rebuild a manufacturing program and generate more student interest.

The case studies will probe faculty perception of the NIMS standards. Manufacturing instructors must be familiar with the NIMS standards and also convinced that the standards are valid and useful before integrating them into the curriculum. These standards have been widely publicized and promoted by various educational and manufacturing groups, but some instructors still may not know the NIMS skills standards or be ready to adopt the standards in the community college programs.

Research questions and hypotheses

This study of curriculum reform in Michigan community college manufacturing programs asks the question: How, if at all, have the NIMS Metalworking Skills Standards influenced manufacturing curriculum reform? As a follow up, a second question further probes the issue: Why NIMS has or has not had an effect on curriculum reform?

The literature review documents support for skills standards and the prominent role skills standards can play in curriculum reform. The NIMS standards are a good example of a skills standards initiative heavily funded by both private industry and by the federal government. These standards were highly promoted during the late 1990s as they were completed and rolled out for educational use. The hypothesis of this study is that by the year 2003 these standards should be reflected in many of the Michigan community college manufacturing programs. In answering these questions about NIMS this study develops a curricular reform model to help explain why curriculum reform occurs or fails to occur in the community colleges.

Sampling and design

This research project begins with a census of the 28 Michigan community colleges. Special consideration was given to the size and scope of the manufacturing programs. Specifically, I attempted to identify in each school a metal working curriculum that could be assessed in terms of the NIMS skills standards. This census provided a snapshot of the current manufacturing programs in Michigan community colleges. I eliminated from further study community colleges that did not support a manufacturing degree program.

The information for this census was drawn from the Michigan Community College Association database, college catalogs, and college web sites. Phone and e-mail contacts were made to ensure that the information was correctly interpreted and stated in commonly used terms for this study. A representative from each institution was asked to verify the information in its final form before it was published. This census identified manufacturing programs offering an associate degree in machining or manufacturing technology. If a viable manufacturing curriculum could be identified, the program was included in part two of the study.

In this study, the population consists of Michigan community colleges that offer at least one associate degree program in machining or manufacturing technology. An initial search of programs showed that all 28 colleges listed recent course offerings in machining related topics. This study focused on the schools offering *current associate degree programs* in this area. Because community colleges continue to evolve and become increasingly comprehensive, assessing "current" status is complex. For example a new emphasis on non-credit training activities and seminars in Computer Numerical Control (CNC) could co-exist with a degree program but receive little attention in the formal documents. Similarly a discontinued program might remain on the books for several years.

The Michigan Community College Dean's Curriculum Guide provided additional data on programs. Follow-up was sometimes needed in this census to determine the exact status of a program. The Dean's guide also helped identify whether or not the program was a full 2-year associates degree program. Some programs offered in manufacturing had similar titles to the degree programs but were of shorter duration – designed around certificate or apprenticeship completion. This study focused on formal associate degree programs, not programs of shorter duration. Short-term programs often did not require the general studies classes that covered NIMS topics such as mathematics and communication skills.

To be included as offering a current associate degree program I also set as a criterion the presence of at least one full-time instructor. ABET/TAC (2003, p. 8) clearly states "Each program must have effective leadership through a full-time faculty member with defined leadership responsibilities for the program". The absence of a full-time instructor might indicate that the program is either dormant, very small, or in a period of transition. Any of these conditions could make the program difficult to assess. One community college had not replaced the retiring full time faculty member responsible for a machining program. Instead the job was "divided up among several adjunct instructors". Upon closer inspection it became obvious that the adjunct instructors did little more than teach the courses that met the minimum enrollment requirements.

Using these criteria, I identified 19 out of 28 community colleges in Michigan with a viable current associate degree program in manufacturing. I conducted a self-report survey of the 19 community colleges with a manufacturing program. Fourteen of those colleges responded. Anderson and Associates (1975) describes a self-report questionnaire as a relatively efficient method of gathering data from a geographically diverse group of individuals. He cautions that the validity of the self-report data may be difficult to determine. In this study the questionnaire explored the current state of the manufacturing curriculum and inquired about plans to reform the curriculum. Several questions about the NIMS standards were included. These questions focused on the primary topic of this study. Also addressed are the external factors to curriculum reform – administration and advisory boards. The numeric data consisted of both ordinal and interval scales. The results of this survey allowed me to draw some initial conclusions about curriculum reform in Michigan community college manufacturing programs. First, I estimated the frequency of curriculum revision. Second, I examined inclusion of the NIMS skills standards in curriculum. Finally, I examined the impact of the administration and advisory boards. The results of the questionnaire are displayed and explained in detail in the Results portion of this study. The dependent variable in this study is the extent to which the survey participants feel that NIMS has affected the curriculum.

For the third part of the study I selected two community colleges based on the influence of NIMS on their curriculum. A site visit to each college allowed me to tour their facilities, examine the curriculum, and interview faculty and staff. These case studies gave a more complete understanding of their perception of curriculum reform and reasons for or against NIMS implementation. This third portion of the study assisted in determining the role that the NIMS standards play in the manufacturing curriculum.

Greene and David (1981, p. 5) argue "the conceptual framework should identify the main facts and events of interest in the subject of study and the main features of the context in which these facts and events are occurring". This study identifies the faculty, administration, and advisory board as the three primary groups affecting curriculum reform. I targeted these individuals for interviews. Interviews with faculty, administrators, and advisory board members helped explain the process of curriculum maintenance and reform. Inspection of the laboratories and review of the existing curriculum allowed me to gain a broader perspective of the current challenges in the manufacturing programs.

The conceptual framework of this study helped to direct the interview questions towards understanding why the schools have chosen their respective paths of manufacturing curriculum development. This combination of census data, questionnaires, and on-site observations generated a more complete picture of the philosophy behind the manufacturing curriculum and the justification for its effectiveness in preparing students to meet the needs of Michigan manufacturers.

Data collection

For the census portion of the study, I developed a database containing the manufacturing program activity of each community college. The census form contained the proper data fields to align with the information readily available in the community college databases. I tried to obtain as much of this data as possible from existing public information. This step minimized the demands on each institution and allowed me to verify the information from multiple sources. Each institution was asked to verify the data before I finalized the results. The information I attempted to gather in this census included:

- college name
- number of students
- geographical location in Michigan

- administrator and instructor contact information
- name(s) of manufacturing degree program(s)
- number of full-time and adjunct instructors in those programs

Because the colleges are encouraged to categorize their programs according to the standard classifications defined in the Michigan Community College Dean's Curriculum Guide, the general manufacturing program titles were easy to identify. The next step involved verifying that the program was an active, full associate degree program. The Dean's guide helped verify this information. Finally, as discussed earlier, I attempted to identify the full-time instructor responsible for this program. This instructor contact was used to verify the accuracy of the program information I compiled. The survey was sent to this individual.

In the second part of the study I surveyed the population of 19 Michigan community colleges identified as having manufacturing programs. I designed a questionnaire to identify the curriculum reform activities in each school and the degree to which the NIMS standards are currently used in the manufacturing curriculum, or will be in the future. This survey was directed towards the lead instructor in the manufacturing department. One constraint of the questionnaire is that the information primarily revealed the *perception* of curriculum reform activity or NIMS implementation in the program. Anderson and Associates (1975) mention several drawbacks common to self-report measures: careless responses, trying to create a favorable impression, or misinterpretation of the question. In other words, this survey did not provide concrete evidence of a successful and complete implementation of the NIMS standards into the curriculum.

The questionnaire, described in the next section, is based on the core issues identified in the curriculum reform model for this study. The question addressing whether or not the instructors follow the existing curriculum helps establish that an agreed upon version of the curriculum currently exists. Questions including the dates of recent or planned curriculum reforms help determine the frequency of curriculum revision. The questions about performance based objectives help establish whether or not the curriculum is based on external performance objectives – a primary component of the NIMS standards. The central questions relating to knowledge of the NIMS standards, and whether NIMS standards are integrated into the manufacturing curriculum, address the primary research question in this study. Finally, the questions about advisory committee and administrative involvement address the curriculum reform issues identified in the conceptual framework.

This information was helpful in placing the 14 responding colleges on a scale that ranged from no implementation of the NIMS standards to complete NIMS integration. In the middle were colleges that expressed some intention of integrating the NIMS standards into the curriculum but have not yet completed the process. Potential colleges for site visits were identified from both ends of this scale. The survey also supplied a general estimate of the level of NIMS awareness and integration in the Michigan community college manufacturing curriculum.

The third portion of the research involved five steps:

1. Selecting two colleges for further study. These colleges were chosen from the survey results placing the colleges on a continuum of full NIMS implementation to no significant steps towards NIMS. Several candidates from each end of the scale were identified and I chose one from each category. The process of asking the lead instructor and an administrator for formal approval for a site visit helped me gauge the level of acceptance I could expect to receive at the college.
2. Informing the lead instructor of my general plan for the site visit and the information I hoped to gather.
3. Visiting the selected colleges to see the manufacturing labs and equipment.
4. Interviewing several persons at each institution to explore curriculum reform and the relationship of NIMS standards to the present manufacturing curriculum. The curriculum reform model identifies faculty, administrators, and advisory board members as the primary groups of individuals affecting the curriculum reform process.
5. Analyzing the official version of the existing curriculum to determine whether it reflected the NIMS standards.

Instrumentation

I developed a questionnaire in the second portion of this study for the 19 Michigan community colleges with manufacturing programs. This survey was cross-sectional in design – meaning that the information would be only collected at one point in time (Creswell, 1994). The questionnaire was designed to address the core curriculum issues described in the conceptual framework in a manner to minimize the respondents' burden. Anderson and Associates (1975) list several advantages of a self-report questionnaire: relatively inexpensive to administer, easily distributed to respondents, and can be treated anonymously. One drawback is the validity of the responses. Because of carelessness in answering questions or the need to make a good impression the answers may not be entirely accurate.

The first step was to develop a cover letter designed to inform the participants of the purpose of the study and to give them enough background information to help them understand the importance of the study (Dillman, 1978). The cover letter begins by explaining the purpose of the survey as "an attempt to investigate the current state of curriculum reform and skills standards in the manufacturing programs of the 28 Michigan community colleges". Following the purpose statement is a brief overview of the terms referenced in the questionnaire, helping the respondents understand the meaning of the questions. An explanation of the program names and codes from the Dean's Curriculum Guide helps the respondents identify the appropriate curriculum within his or her institution. The Stark and Lattuca (1996, p. 9) definition of a curriculum as an "academic plan...including purposes, activities, and ways of measuring success" is also included in the cover letter to clarify the meaning of this important term. Finally, the cover letter identifies the intended respondents of the survey as "full time community college instructors whose primary teaching loads are assigned in the machining / manufacturing programs".

Creswell (1994) stresses the importance of pilot testing a survey to make sure the questions are easily understood and to avoid multiple interpretations. This questionnaire was pilot tested on a former manufacturing instructor and a former dean of a manufacturing department. These two individuals provided valuable feedback, resulting in several format and wording changes to the survey instrument. The first version of this survey included questions with an ordinal scale attached. During the pilot test it became apparent that yes or no answers, with room for comments, better fit the nature of the questions. A category of "unsure" was also added. The comments allowed the respondents to qualify the answer and give additional information (Anderson and Associates, 1975).

The ten questions address five important issues identified in the conceptual framework of this study. One measure of curricular reform activity is how often it occurs. The two questions involving dates of curriculum reform allowed for an interval scale answer. The topic of performance based student assessments was raised in one question and followed up with another question asking about external validation of these assessments. Because external assessments were so highly emphasized by both NIMS and ABET, this topic was crucial in assessing the level of NIMS implementation.

Central to this questionnaire were the two questions directly about NIMS. The respondents were asked if they used NIMS now or planned to in the future. Respondents planning to implement NIMS in the future indicated that they support the NIMS standards but have not yet been able to integrate them into the curriculum. Finally, the two questions involving the administrative and advisory committee in the curriculum reform process helps to complete the assessment of the curricular reform model developed in this study.

The questionnaire was designed to address four valid reasons against using NIMS. The first valid reason for not using NIMS is that the instructors or institutions are not aware of the NIMS standards or do not have enough information about NIMS to make a decision. Second, an instructor might disagree with the standards. As an example, there may exist a pedagogical reason for not adopting the NIMS standards. Third, support from administration or local advisory boards may be lacking regarding NIMS. Finally, the possibility exists that other externally validated skill sets are currently used to drive the curriculum reform process. These could all be considered as potential reasons for institutions to not adopt NIMS.

Also included with the survey was the consent form authorized by the University Committee on Research Involving Human Subjects (UCRIHS). The final version of this survey was submitted to UCRIHS for approval before it was sent out to respondents. The consent form accompanied the survey and also helped explain the nature of this study. The time required of the respondent is estimated at between 20 and 40 minutes. Confidentiality issues are also explained. In this study, I am the only one who can identify the respondents of the individual surveys.

This questionnaire was e-mailed to the lead instructor in each institution, as identified in the census. To maintain consistency in the survey results only one instructor was surveyed in each institution. Additionally, I did not want the questionnaire to be completed by administrators or part-time faculty as they could skew the results of the survey. Before the questionnaire was sent, I e-mailed each recipient to make sure he / she was available and willing to fill out the survey. This step also allowed me to confirm that I had the right e-mail address. E-mail was the easiest form of communication with the instructors as all of the institutions had a reliable system of e-mail and the instructors seemed very comfortable with it. Two instructors chose to print the survey and mail their responses. They both cited a perceived lack of confidentiality in the e-mail systems they used at work. One other instructor asked me to e-mail the questionnaire to his personal address.

The following steps were taken to ensure a high response rate (Dillman, 1978). Three weeks after e-mailing the questionnaire I received 9 responses. I then e-mailed a reminder to the remaining 10 instructors and received 3 additional responses (2 requested that I re-send the survey). Finally, after another 3 weeks, I tried to contact the remaining 7 instructors by telephone and subsequently received 2 additional responses. Overall I received 14 responses out of 19 surveys, a 73% return rate.

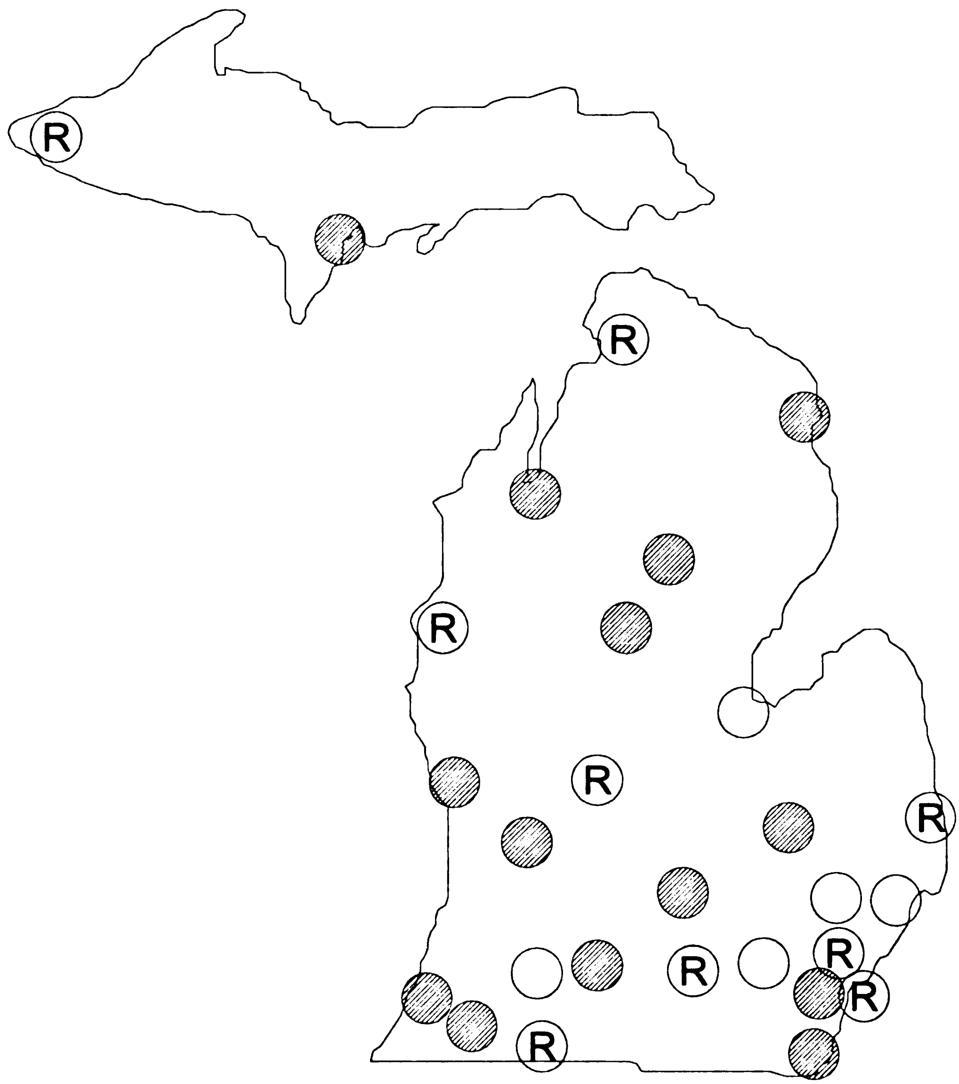

Figure 4: Geographic Locations of Community Colleges

To make sure that the 14 respondents represented the population of 19 community colleges with viable manufacturing degree programs, I looked for bias in geographic distribution. Figure 4 shows the general locations of the 28 Michigan community colleges. The nine locations marked with an "R" represent the institutions that were removed from further study because they did not have a viable manufacturing program. Based on Figure 4, these 9 colleges were evenly distributed throughout the state with equal number representing urban and rural locations. The 5 non-responding colleges are identified with a blank circle at their location. These colleges were fairly well distributed with a somewhat higher number coming from the southeast portion of the state.

The third step in this study – the site visits – helped clarify the data from the surveys and probed deeper into the curriculum reform process. The overall study is a mixed methods design where the survey results contain primarily quantitative data and the site visits result in qualitative data. Creswell (1994) explains that alternative sources of information can result in a "triangulation" of data, using one source to help clarify another source. The survey results, combined with the data from the case studies, should help to answer the questions proposed in this study. He goes on to say that a mixed methods design adds "scope and breadth" to a study. This study best fits the model of a "two phase design", where the first phase is quantitative and the second phase is qualitative.

In their classic description of research designs, Campbell and Stanley (1966) propose three types of pre-experimental designs. The one that best fits this study is called the "Static-Group Comparison". This design involves the study of one group that has felt the effect of a given factor and one group that has not felt the effect. For this study, one of the sites I visited has experienced curriculum reform based on the NIMS standards. The other site has not used NIMS to drive its curriculum. These sites are located several hundred miles from each other and represent two different views regarding NIMS implementation. The initial sites selected were very cooperative and I did not have to try to gain access to alternate sites.

The site visits portion of this research also fits into the framework of a multiple case study (Greene and David, 1981). This part of the research may provide the most useful information to policy makers interested in both the factual results of this study – how many community colleges use the NIMS standards – and the reasons for a given course of action. In preparation for the site visits I developed an interview protocol. Protocols help focus the interview process, avoiding the gathering of "superfluous information". They also maintain consistency, allowing data to be compared across interviews and site locations (Miles and Huberman, 1984).

The protocol begins with a careful introduction of myself and the purpose of the study (Cohen and Manion (1994). I negotiated a schedule so that those being interviewed could plan their time accordingly. I also explained the issue of confidentiality before the interviews. The lead instructor in the program acted as the "point person" to help schedule interviews and provide me with curriculum materials. No recording devices were used in these interviews. I relied on interview notes and wrote up the interviews on the same day they were conducted. Each interview followed a printed interview guide that was also given to each participant before the interview. Finally, thank you notes were sent out to show appreciation for the time given by each participant.

Miles and Huberman (1984) additionally suggested the use of a "contact summary sheet". This step is an efficient way of compressing interview notes into a concise form that summarizes the data and aids in comparison with other interviews. This form contains a heading with space for participant name, a checkbox for participant position, and the date. Several categories on this page allow the responses to be grouped under the headings of administrative support, local industry support, and faculty time spent on curricular issues. Another part of the page is devoted to NIMS issues. These include reasons for or against using NIMS, future plans for NIMS, and perceptions of the NIMS standards. By completing one of these forms soon after each interview I could reorganize my notes into a useful overview of the interview.

Anderson and Associates (1975) explain the advantages of a structured interview over an unstructured interview. Although a structured interview is more uniform and easier to compare across respondents, the unstructured interview allows for additional topics and ideas to be discussed. During the site visits I was careful to ask the same questions of each person I was interviewing. For instance, during lunch we would likely be engaging in “shop talk” that covered a wide variety of topics. I would then ask that we “switch gears” and go through the structured list of questions. This process helped the respondent know that we were entering the structured portion of the interview. One advantage of my first-hand experience with manufacturing curricula is that I could understand the terminology and jargon used in the interviews. The disadvantage was a temptation to make assumptions about certain aspects of the site visits based on prior knowledge or my experience in the field (Krieger, 1991).

Finally, I address the issues of institutional access and acceptance. Cohen and Manion (1994) point out "investigators cannot expect access to a nursery, school, college, or factory as a matter of right". From my own experience as a community college instructor, I know that we tend to protect our turf, avoid unnecessary interruptions, and become suspicious of any activities associated with "research". Erickson (1985) reminds us "negotiation of entry is a complex process" (p.126). He explains the need to repeatedly state the purpose of the research to individuals being studied, helping assure them that they are not being personally evaluated. My first point of contact was with the lead instructor at the institutions I wanted to use for case studies. I tried to be honest as to why I was doing the study and what I would do with the results. The request was written as follows:

Dear ,

In order for me to conclude my study on machining curriculum in Michigan community colleges I would like to complete a few site visits. This would involve spending some time on campus performing the following activities:

- tour of machining labs
- interview of lead instructor
- review of existing machining curriculum
- brief conversations with several of the following persons
    - adjunct instructor
    - school administrator
    - advisory board member
    - local employer

If you would be willing to consider this request I would also formally request permission from your dean or other appropriate administrator. This could be planned during a day when you plan to be on campus but may have a little time between classes to meet with me. I would like to do this sometime after spring break in March.

Thank you for your consideration of this request.

All contacted individuals agreed to the site visits and interviews.

The timing of the survey and site visits was critical. The beginning and end of the semester is a very busy time for instructors. Community colleges are often deserted during the summer. I chose a mid-semester time period to conduct the survey and site visit portions of the study. The survey was done during October and November of the fall 2003 semester. The site visits were done during March of the 2004 winter semester.

Data analysis

The census in the first part of this study was used to identify the existence of viable manufacturing *programs* in Michigan community colleges. The second part of the study uses a survey to explore viable manufacturing *curriculum* in these programs. The data from the survey are used to begin answering the questions asked in this study. The first question regarding whether or not the NIMS standards are driving curriculum reform is an objective question than can be answered using quantitative data. The answers that I received from the 14 community colleges provide a definitive answer. This study continues with the next question – why are these standards used or not used? The questionnaire is designed to address several possible reasons – ignorance of the standards, disagreement with the standards, or no support from administration or local industry. The yes / no answers are converted to percentages to better quantify the results.

In addition to answering the questions regarding the NIMS standards, this survey also answers other issues raised in curriculum reform. The question addressing whether the curriculum is understood and followed by all instructors helps establish the existence of a coherent curriculum. A negative response to this question identifies a lack of clarity in the existing curriculum or a general disregard for its content. Several questions were also analyzed in pairs. For example, the two questions regarding dates of past and future curricular reform activities provide a numeric estimate of revision cycles. Graphs of these results along with the average and standard deviation of the revision frequencies are used to demonstrate the existence of curricular reform activities. The final questions help portray the roles of administrative support and advisory committee support in curriculum reform.

I use the yes/no nature of these questions to generate a "first impression" of the current status of curriculum reform in Michigan community college manufacturing programs. The "unsure" categories are intended to discourage guessing for questions where the respondents did not understand the question or know the correct answer. The comments are listed as supplemental information and are discussed in the results portion of the study. The comments were also used to help develop the interview questions in the qualitative portion of the study.

The qualitative case studies focus on detailed aspects of curriculum reform. Following a structured case study plan enabled both individual case and cross-site analyses. This qualitative study followed the Miles and Huberman

(1984) process of collecting the data, reducing the data, displaying the data, and drawing conclusions. In this study I use both "narrative text" and "cross-site analysis" to report the data. Also of interest is the comparison of multiple viewpoints within the organizations. For this study I compared the responses of administrators, instructors, and advisory committee members.

This study presented some unique challenges in that it focused on a relatively small academic community. To protect the confidentiality of the respondents I have minimized the use of direct quotations or detailed descriptions of personal and institutional characteristics in the results portion of this study.

Case Study Selection

Green and David (1981) discuss the importance of selecting the case study sites. They explain "the goal of sample selection is to obtain a set of cases which, taken together, contain variation on key explanatory factors representative of their variation in the target population" (p. 6). Although two sites may be considered minimal for many types of data analysis and generalizations (Miles and Huberman, 1984), these sites provided a reasonable amount of data to help address the primary issues in this study. Two similarities existed between the sites. They were both identified as having an active manufacturing program (part 1 of the study), and they both returned the questionnaire from this study (part 2). The variable factor between the sites was the use of the NIMS standards in their manufacturing curriculum.

The results portion of this study shows that many programs did not use the NIMS standards to focus their manufacturing curriculum. This result meant that many schools could be chosen from that sector. Only two programs currently use NIMS – leaving a rather small choice for potential site visits. In both of these categories I was careful to choose sites that had experienced some stability in the past several years. Of the 14 sites that responded to the survey several were facing a crisis of one type or another. These problems included instructor turnover, low enrollments, and possible merging with other programs. I felt that these sites would be more difficult to study and compare with a stable program. Another factor is the transition to open entry / open exit programs based on a self-paced learning environment. Although that environment does not present a problem in curricular development, the transitions were recent and in the process of further adjustment. I also checked with NIMS to see if I had missed any community colleges that were NIMS certified but had not returned the survey. No other community colleges in Michigan were NIMS certified. Several other factors such as institutional size, location, or service area seemed to affect the presence of a viable manufacturing program, but did not appear to influence the levels of curriculum reform in the manufacturing programs.

The site visits followed up on the survey to help clarify the data collected and to further probe the issue of how curriculum reform occurs. The first qualification for a site was that it had to have a viable manufacturing associate degree program. The second characteristic was that the site was one of the 14 colleges responding to the survey. The survey helped place the various programs on a continuum ranging from fairly traditional programs that have not reformed the curriculum to the more progressive institutions with actively implemented NIMS standards. In selecting the sites I deliberately chose one institution from each end of that scale. This process allowed for a comparison between the two sites and for an explanation of why each chose a particular path of curriculum reform. Regarding the issue of site access and acceptance, Cohen and Manion (1994) warn that researchers do not have the "right" to study any program or group of individuals they desire. Rather the negotiation into a case study site must be carefully addressed. From the potential sites identified in the survey, I chose sites that represented each end of the NIMS implementation scale and sites to which I felt that I had a reasonable chance of access.

"Traditions" Community College is located in a large urban area with a high level of industrial activity. The Machining Technology program has been in existence for several decades and is considered a rather strong program. The curriculum is well established and has not been intentionally aligned with the NIMS standards. Traditions Community College has an occupational administrator who is recognized as a leader and promoter of industrial programs in Michigan. This administrator takes a long view of the vitality of the manufacturing program and has a firm grasp on the mission of the community college. The instructors at Traditions realize that along with good funding and support for their program come high expectations for curriculum development and coordination between programs. One instructor nearing retirement is proud of the solid machining fundamentals taught at Traditions, but realizes that a new instructor will need to bring the program up to a new level of technology, reflecting the changing nature of the manufacturing industry.

"Innovations" Community College is located in a rural area of Michigan with a much weaker industrial base. The instructors have taken an aggressive approach towards curriculum reform and adherence to the NIMS standards in the Manufacturing Technology program. Innovations Community College faces several unique challenges. The past few years have seen a large turnover in the college leadership. Although the former administration showed strong support for the manufacturing department, the new management seems a bit tentative about the direction of the manufacturing program. Innovations Community College is one of the smaller community colleges in Michigan, meaning that economic resources are also limited.

A few of the large industrial employers have either moved out of the area or are changing the way they do business to reflect the economic realities of the current manufacturing environment. One belief is that manufacturing will continue to move from the area. Another belief is that the remaining employers need a good local training source for new employees for the companies to remain and grow in that geographic area. The manufacturing department hopes that the administration acts in line with the second belief. The manufacturing department at Innovations Community College is especially vibrant and aggressive. They were one of the first Michigan community colleges to actively promote NIMS and integrate the NIMS standards into the curriculum. The facility and instructors became NIMS certified and the students have taken the certification tests.

Another curriculum issue that complicates matters at Innovations Community College is the definition of the "community" that it serves. Like most other community college districts in Michigan, the local manufacturing companies have some unique training needs that must be addressed. A restricted local economy has meant that Innovations Community College has an unusually high number of students who will be continuing their education and career pursuits beyond the local area. This need requires a curriculum that provides for a strong academic and occupational program beyond local employment opportunities. Special care has been taken in the curriculum to provide this exposure to the students.

Chapter 4

RESULTS

Census

This census of manufacturing programs in Michigan community colleges was completed in the summer and fall of 2003. Most of the information published by the Michigan Association of Community Colleges described programs from the 2001-2002 academic year. This census was first compiled from the listing of the 28 community colleges on the Michigan Community College Association website (www.mcca.org). Additional information was also available from the Michigan Community College Network (www.mccnet.educ.msu.edu), as well as from the individual college web sites. Specific program information was obtained from the Michigan Community College Dean's Curriculum Guide. This guide listed all of the program names and corresponding CIP codes for each individual college. Table 7 contains a summary of the census. A more detailed version of the census is found in Appendix A.

College 2001/2002 Program Enrollment	**Number of Mfg. Programs**	**Number of Instructors**
Alpena Community College 2776 students	1	3 full time shared with other departments
Bay de Noc Community College 2500 students	1	1
Delta College 10,500 students	2	5 full time 3 part time
* Glen Oaks Community College 1152 students	1	no full time instructor
* Gogebic Community College	none	

933 students		
Grand Rapids Community College 13,741 students	2	2 full time 3 part time
Henry Ford Community College 12,000 students	2	1 full time 3-5 adjunct
* Jackson Community College 5092 students	none	
Kalamazoo Valley Community College 6391 students	2	1 full time 7 part time 1 full time adjunct
Kellogg Community College 5539 students	2	1 full time 2 part time
Kirtland Community College 1567 students	3	1 full time
Lake Michigan College 3796 students	2	1 full time several adjunct
Lansing Community College 13,989 students	4	2 full time 2 part time
Macomb Community College 12,775 students	2	1 full time 3 part time
Mid Michigan Community College 2775 students	1	1 full time 1 part time
Monroe Community College 3757 students	1	2 full time 3 part time
* Montcalm Community College 1963 students	1	1 full time 3 part time
Mott Community College 7955 students	1	1 full time 2 part time
Muskegon Community College 4817 students	2	1 full time 2 - 3 part time
* North Central Michigan College 2437 students	none	
Northwestern Michigan College 4810 students	1	1 full time 1 part time

Oakland Community College 25,126 students	4	1 full time 1 part time
* St. Clair Co. Community College 6047 students	1	2 part time
* Schoolcraft College 12,830 students	1	Several full time from other departments
Southwestern Michigan College 3120 students	3	1 full time 1 part time
Washtenaw Community College 12,950 students	2	2 full time
* Wayne County Community 11,660 students	1	??
* West Shore Community College 1233 students	1	2 part time

Table 7: Directory of Michigan Community Colleges

Surprisingly, all 28 colleges indicated some recent course offerings in machining related topics. The programs listed most frequently were:

Program Name	*Number of colleges*	*% of colleges*
Manufacturing Technology	15	54%
Industrial Machine / CNC Technology	13	46%
Machine Tool Technology	13	46%

Further investigation showed that several of these schools were not actively offering machining related programs. In some cases the programs were being reduced or eliminated. Manufacturing programs are facing cutbacks because of recent budget constraints. Additionally some programs are fighting a perception that manufacturing companies will not be hiring many employees in the near future. As a result of this census, 9 of the 28 community colleges were identified as not having a viable manufacturing program and were eliminated from further study. These colleges are noted with an asterisk (*) in front of their name in Table 7. As discussed in Chapter 3, a viable program in this study is a full 2-year associate degree program currently accepting students. At least one full-time instructor should be assigned to this program, and the scope of the program should include machining or metal forming topics. The 19 schools with viable programs are evenly distributed throughout Michigan on a geographical basis.

The size of Michigan community colleges varies from Gogebic with 933 students to Oakland with 25,126 students – a range of over 24,000. The average of all 28 colleges is 6938 students with a standard deviation of 5687. Of the 9 colleges removed from further study, the average size was 4816 with a standard deviation of 4579. This group of 9 colleges included the three smallest Michigan community colleges – Gogebic, West Shore, and Glen Oaks. Although the size of the college and the size and vigor of the manufacturing programs appear uncorrelated, the very smallest colleges are less likely to have a viable manufacturing program.

Survey

The questionnaire was sent to 19 of the 28 Michigan community colleges. The return rate was 74%, with 14 questionnaires of the original 19 returned. Most responses reflected agreement between the various colleges. The small number of unsure or unanswered questions indicates that the respondents understood the questions and had a firm opinion on each issue. The comments helped clarify some of the answers and provided interesting insights into some of the curriculum issues. Table 8 lists the 14 colleges that returned the survey and the number of relevant programs identified.

College Name	Size	Number of Mfg. programs
Alpena Community College	2776 students	1
Bay de Noc Community College	2500 students	1
Grand Rapids Community College	13,741 students	2
Henry Ford Community College	12,000 students	2
Kellogg Community College	5539 students	2
Kirtland Community College	1567 students	3
Lake Michigan College	3796 students	2
Lansing Community College	13,989 students	4
Mid Michigan Community College	2775 students	1
Monroe Community College	3757 students	1
Mott Community College	7955 students	1
Muskegon Community College	4817 students	2
Northwestern Michigan College	4810 students	1
Southwestern Michigan College	3120 students	3

Table 8: Community Colleges Responding to Survey

The average size of the 14 colleges that returned the survey was 5940 students with a standard deviation of 4271. These colleges were evenly distributed across the state and represented a size range of Lansing with 13,989 students to Kirtland with 1567 students. Appendix C contains the detailed results of the survey.

The survey provides objective data regarding the primary question in this study: How, if at all, have the NIMS standards influenced manufacturing curriculum reform? Question 6 directly addressed that question by asking whether or not the NIMS standards were used. 86% of respondents indicated that the NIMS standards are not used in the present curriculum. Only two colleges have committed to using the NIMS standards. This question frames the rest of the study: considering all the time and resources spent on the NIMS standards, why are they not being used in the Michigan community colleges?

Questions 5 and 7 begin to answer the "why not" question. Every response to Question 5 indicated that the respondents were aware of the NIMS standards. Is it an issue of timing? Are the NIMS standards so new that the community colleges have not yet had a chance to reform their curriculum to NIMS? Question 7 elicited the most mixed response from this questionnaire. When asked whether they in the future intended to use the NIMS standards in the manufacturing curriculum 3 answered yes, 7 answered no, and 4 were unsure. In retrospect, the question does not give clear guidelines to the two schools that already used NIMS. As I reviewed the individual surveys and found that the schools that answered yes included the two that already use NIMS, I discovered that only one more school is planning to use NIMS. The four unsure responses indicate that not all schools have made a firm decision on this issue.

Are the faculty in the manufacturing programs not using the NIMS standards involved in curriculum reform at all? On the issue of curriculum reform and revision, these 14 colleges apparently take quite seriously the need for updated curriculum. A majority of the respondents indicated curriculum revisions within the last few years. Many of the respondents also indicated curriculum revision activities are scheduled to occur in the next few years. The average curriculum revision process appears to reflect a five-year cycle. Question 1 indicates that the average major curriculum revision occurred 3 years ago. The results are shown in Figure 5.

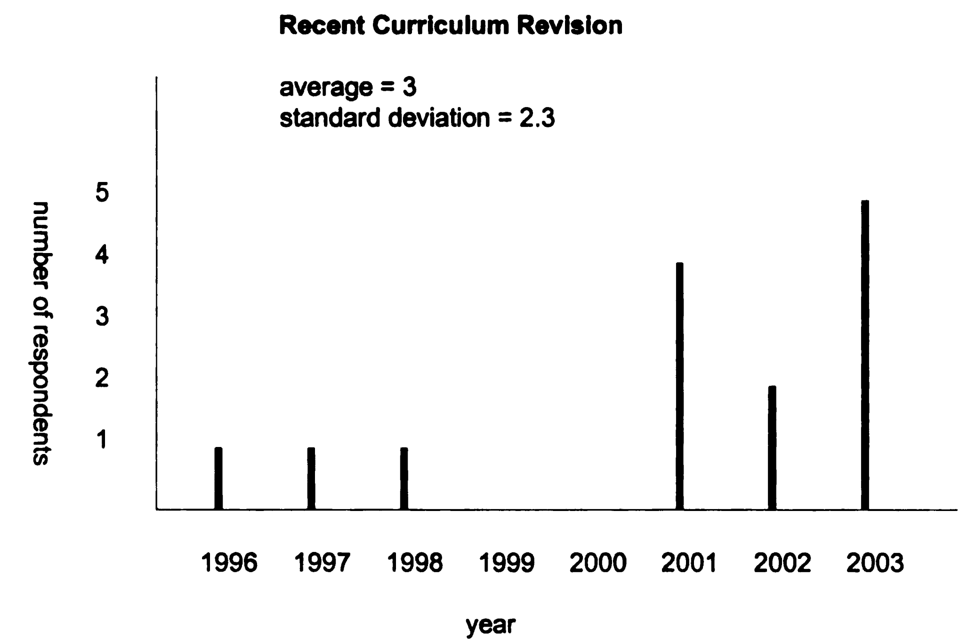

Figure 5: Recent Curriculum Revision

Question 8 follows up on this same topic, asking about the anticipated dates of future curriculum revision. Again these answers reflect a commitment to keep the curriculum updated, with the average revision anticipated in less than 2 years. Figure 6 shows the results of Question 8.

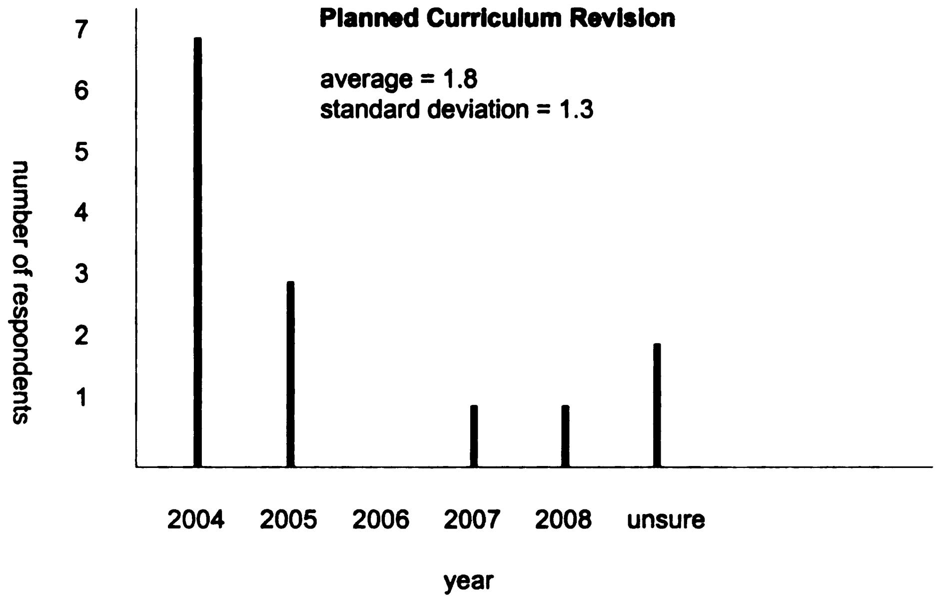

Figure 6: Planned Curriculum Revision

Questions 2-4 probe deeper into the existing curriculum. Question 2 asks whether or not the curriculum is generally understood and followed by those teaching in the department. There appears general agreement on the adherence to the curriculum, as 93% answered yes to this question and the remaining response was unsure. The respondents feel that their curriculum is generally understood and followed.

Question 3 sets the tone for the next several questions by asking whether or not lab performance-based student assessments are used. There was complete agreement that lab performance-based student assessments are used. The intent of this question was to establish a basis for Question 4, as it is very unlikely for laboratory-based classes – such as machine shop – to rely solely on written assessments for student achievement. The results from Question 4 were surprising. Only one respondent indicated using external validation of the performance-based student assessments. Much current literature on community college curriculum reform (Jacobs, 2001; Merritt, 1996; Salzman, 1998) recommends that assessments be externally validated. One of the principles espoused by NIMS is that lab assessments be externally validated. This criterion means that lab projects are specifically designed to meet industry standards of student performance. Apparently most community college instructors do not agree with this criterion and use assessments of their own design. One of the two colleges using NIMS answered "no" to this question, which leads me to believe that they teach the NIMS standards but do not test to them. Perhaps the 13 schools answering "no" to this question use internally generated assessments that they feel are compatible with what industry requires.

The respondents seem upbeat on the issues of future curriculum development activity. A majority (78%) felt that they had administrative support for curriculum reform. One respondent answered "no" and two were "unsure" of administrative support. About three-fourths – 71% - indicated support from advisory committees and local employers.

The 29 comments that were added to the questionnaires provided valuable additional information. Many of these comments were used to help frame the topics for the site visits. Question 1 and 8 asked about dates of past curriculum reform and anticipated dates of future curriculum reform. Several respondents indicated that curriculum reform was initiated through college-wide changes in general requirements or in response to new ways of course delivery - such as open entry / open exit course structures. Other comments indicated that curriculum reform has occurred because of structural changes in the college. One example of structural changes involves horizontal expansion (Bailey and Morest, 2004) with new programs added to the manufacturing departments. Finally, several more comments reflected that curriculum reform should be an ongoing process. Continual tweaking and adjustment of the curriculum is needed to keep the programs current.

Regarding the issue of whether or not the manufacturing curriculum is understood and followed, one respondent speculated that very small department sizes help to explain uniform application of the curriculum. This finding is probably true for many of the institutions that were surveyed. Adjunct faculty in particular may not be well versed with the official curriculum.

Many of the remaining comments help answer the question of why NIMS is not used in the manufacturing curriculum. Several comments stated that the NIMS standards were not a good fit to the existing program goals and objectives.

NIMS may have looked promising initially, but the implementation details became too great an obstacle. The advisory committees have not been supportive of the NIMS standards. Similarly, although administrators valued curriculum reform in general, little support for the NIMS standards appeared to exist. Additionally, some instructors prefer to work on curriculum without interference from administrators. Likewise certain administrators, through their silence or non-involvement, give tacit approval of whatever curriculum development is taking place. A few other respondents took a more pragmatic approach, realizing that most administrators and advisory committee members probably will not play an active role in curriculum reform – only an advisory role. These two issues regarding administrative and advisory committee support of curriculum reform are explored further in the case studies.

Case Studies

The data from the case studies are displayed in two different ways. First I use "narrative text" to explain manufacturing curriculum reform at each college (Miles and Huberman, 1984). Next I use a "cross site analysis" to gain additional insight into these institutions (Greene and David, 1981). Appendix D contains a site visit protocol and an interview summary sheet, as discussed earlier in this study. Following are some of the interview responses and resulting observations of curriculum reform and alignment with NIMS standards.

The NIMS standards have not greatly influenced the curriculum at Traditions Community College for several reasons. First, the program was well established before the introduction of NIMS, and the NIMS standards were not a good fit with the existing program. The current program included many topics not addressed by NIMS but considered important for graduation or transfer requirements. In other words, NIMS required more depth and less breadth than the existing program. Another of the difficulties with curriculum reform at Traditions is the challenge to add program offerings – such as NIMS certification - while also supporting all of the existing classes. Expanded offerings result in smaller class sizes, which then necessitate merging or canceling of classes. This "legacy" can adversely affect curriculum reform in colleges that currently serve a core group of constituents. Reasons for change are weighed against the need to continue programs already considered successful.

The variety of students being served by the program also created many obstacles for implementation. The mix of students in a typical manufacturing class could include apprentices, transfer students, and those seeking new career opportunities. Although many of these students need to become familiar with manufacturing processes, they do not necessarily need to demonstrate mastery of specific operations. The NIMS standards seemed more appropriate for a focused training program than for traditional associates degree coursed offerings.

Finally, there were few incentives to implement the NIMS standards. Statewide efforts to apply the standards have lost their momentum. Local industry seems ambivalent about the standards. The respondents felt that the students would not be well served by the additional training and assessment.

One advisory board member felt that "NIMS seems to be very bureaucratic and expensive".

Respondents believed that advisory committee and local industry support exists, but there is room for improvement. One administrator felt that some of the course offerings were unique and already reflected the special requests of local companies. A faculty member admitted "working closely with advisory boards becomes time consuming and emotionally draining". An advisory board member stated "industry people are busy, but are willing to serve as long as it is not just a political event where the group socializes and rubber stamps the program." Keeping advisory boards actively involved in curriculum reform remains an on-going challenge.

Future plans for manufacturing curriculum at Traditions Community College call for greater use of technology and better integration with other programs. Respondents are convinced that students must be able to synthesize a variety of job skills rather than specialize in a small segment of the manufacturing job market. Several respondents felt that the curriculum needed to be better promoted within the local manufacturing companies and to the community at large.

Another issue with curriculum reform at Traditions involves the time allotted to faculty for serious course development work. The administration realizes that instructors do not have the extra time during normal semesters because of high teaching loads. Curriculum development occurs during semester breaks. Some instructors voluntarily select "overload" courses with additional pay

– increasing their average workload. Instructors stated that they did appreciate in-service days and time at seminars that encourage curriculum development. However, guidelines for how much work instructors are expected to perform outside of normal classroom activities are almost non-existent.

Innovations Community College saw the emerging NIMS standards as a way to improve its program and gain status through NIMS accreditation. Innovations was one of the first Michigan community colleges to become NIMS accredited and to reform its curriculum to meet the NIMS guidelines. Although the NIMS standards were helpful for laboratory upgrades and curriculum revision activities, the instructors have become a bit disillusioned with the NIMS organization. Frequent complaints include poor communication with NIMS, unrealistic student assessment procedures, and excessive charges for NIMS administrative activities. Innovations Community College is not likely to promote the NIMS standards in subsequent curriculum development activities. One instructor proposed that a professional society such as the Society of Manufacturing Engineers (SME) would be better situated to maintain and promote training and educational standards.

Each class in the curriculum at Innovations Community College is organized into a comprehensive 3 ring binder, complete with Power Point presentations for each lesson. This step ensures uniform application of the curriculum among faculty and is an asset to adjunct instructors. A well-designed curriculum does not discourage continual tweaking and improvement of the program. One instructor commented that with the current level of curriculum development, continuous improvement would better serve the program than waiting for major curriculum updates every five years or so.

Faculty members seem to spend more time than normal on curriculum issues at Innovations Community College. Much of this work is done independent of administrative guidance or support. One instructor is a self-described workaholic, spending large amounts of time during the summer working on curriculum issues. Another instructor believes that a fundamental part of curriculum development involves working closely with manufacturing companies to stay current with industry practices. Perhaps this instructor's recent work in industry, strong ties to several companies, and involvement with professional organizations make it easier to maintain contacts with the manufacturing industry. Again, much of this activity is done outside of the normal college teaching requirements.

One interesting topic noted as a comment on the questionnaire and also brought up in the "unstructured" discussions is the statewide push towards open entry / open exit (OE/OE) curricula. Several of the state funded curriculum projects for the new M-Tech centers specified the inclusion of the NIMS standards and were required to follow the OE/OE format. This curricular model promotes flexibility because the learner can begin class anytime, not waiting for the official start of each semester. Emphasis is placed on active learning, and the time to complete the learning activity will vary according to the learner's ability and productivity. The manufacturing department at Innovations remains strongly opposed to the concept of OE/OE courses. Other community colleges in

Michigan have been promoting these classes as a way to optimize instructor efficiency and attract students, thereby requiring flexible learning options. The perception of this department is that the content of the OE/OE courses can become watered down, and a large number of community college students do not possess the personal time management skills necessary to succeed in these classes. Additionally, safety issues are raised when students work on machinery without proper instruction and supervision.

Cross-site analysis

According to Miles and Huberman (1984) qualitative data are first analyzed as they are collected because the researcher must write down his or her version of that data. The data are further analyzed as they are reduced and summarized. One further method of data analysis is through the creation of data displays. By arranging and comparing the data, additional patterns may become evident. Appendix E contains the data tables of the cross-site analysis. The individual qualitative responses from the interviews helped explain the course of action taken by these two schools regarding curriculum reform. The cross-site analysis helps compare the similarities and differences between the schools. In the first part of the cross-site analysis I address the three factors affecting curricular reform – faculty, administration, and the advisory committee. These factors are part of the curricular reform model for this study and are addressed in both the survey and the site visits.

Traditions appears to have a higher level of administrative support for curricular reform. One of the administrators has a great deal of experience with occupational programs and is anxious to see them transformed to fit current industry expectations. Innovations College has experienced a recent change in administration. The new administration is not providing the same level of support and encouragement to the manufacturing department as the old administration. The Innovations instructors would welcome any positive support from the administration. They would like to see realistic goals and targets for the program. However, they would rather work independently than face administrative criticism and interference in their curricular activity. The administration at Innovations feels the program must "stand on its own" but does not follow through with a financial description of that statement. One factor that may explain a much higher level of curriculum reform at Innovations is that the instructors feel somewhat threatened and are taking a very proactive approach to maintaining their program. Pressures are less visible at Traditions. In both colleges the administration expects the faculty to find time on their own for curriculum development work.

In both colleges the faculty remain central to the process of curriculum reform. With regard to faculty time spent on curricular issues, this study reinforces Grubb's (1999) findings – community college instructors are very busy with teaching and classroom related activities. Therefore most curriculum development will occur during the summer and semester breaks – if the instructors are self-motivated. The administration is reluctant to pay for additional "release time" for curricular activities, although at Innovations Community College one administrator suggested the faculty could apply for grants to help with curriculum reform. At Traditions an administrator mentioned that the faculty should network to a greater degree with other schools on curricular issues. A cooperative curriculum approach could reduce the pressures on individual instructors and draw from a greater pool of manufacturing knowledge. An Innovations instructor thought that faculty could best handle curricular issues without interference from the administration. Again, this comment reflects the belief that administrators can be more of a hindrance than help for curriculum reform.

Most of the individuals interviewed – faculty, administrators, and advisory board members - admitted that local industry and advisory council involvement in community college curriculum are both necessary and problematic. One difficulty expressed at both colleges was that companies are too busy for active involvement in the curriculum. Another concern was that the advisory council members were primarily looking out for their own best interests.

The advisory committee members had concerns of their own. They felt that they were being used mostly for political purposes, and that higher education is slow to respond with changes they recommend. An instructor at Innovations explained that because of the rather small local manufacturing base students also had to prepare for jobs or further education in other parts of the state. This circumstance means that advice from the local advisory board was tempered by regional and statewide information.

On a more positive note, a Traditions instructor and an administrator mentioned several examples of special classes created to meet the unique demands of local industry as a result of advisory board involvement. One Innovations instructor felt that local support for the program is improving and the advisory board is helping the college with a better recruiting and promotional strategy. An administrator at Innovations believes that local companies can help the manufacturing program incorporate some of the new business practices that that local companies have recently implemented.

The next portion of the cross-site analysis deals with specific curricular issues addressed in the curriculum reform model. These comments help explain why NIMS has not had much effect on the curriculum. On the issue of recent curriculum reform both Traditions and Innovations seem to justify their chosen course of action. Traditions boasts of a solid program with strong fundamentals. Respondents admitted that they do not quickly jump on new ideas and that they have viewed NIMS with a bit of skepticism. Respondents at Traditions acknowledge that a new full time instructor is expected to take the program to a higher level of technology and innovation. Although NIMS will continue to be a useful benchmark for evaluating the curriculum, respondents say that the introduction of new technology will become a higher priority. The instructors at Traditions claim that they are trying to promote classes that appeal to more students and challenge a wide range of student ability. They are also seeking better integration between programs – such as manufacturing and industrial design. The NIMS standards do not appear to fit these goals.

Interview data show that Innovations quickly embraced NIMS and reformed the curriculum to meet the new standards. Respondents stated that they expected a much higher participation rate with community colleges throughout the state. Although many respondents later became dissatisfied with the NIMS organization, they felt that the laboratory facilities and the curriculum have improved as a result of NIMS implementation. Innovations would likely support any new standards or certifications that have broader support in Michigan.

Respondents at both colleges expressed similar reasons for attempting curriculum reform, although actual curriculum change was more apparent at Innovations. Reasons for curriculum reform include new technology, new trends in industry, and college wide changes in degree requirements. Respondents at both schools believed that NIMS is not widely supported by Michigan community college educators or by Michigan manufacturing companies. The statewide push towards adoption of NIMS seems to have failed. Respondents from Traditions felt that NIMS was not a good fit with their program. They place more emphasis on local needs and advisory board input than on national standards. At Traditions manufacturing faculty members have already experienced difficulty with offering an expanded selection of courses without increasing total enrollment in the manufacturing program. This development causes more classes to be cancelled or merged. However, respondents believed that the NIMS standards were a helpful benchmark for curriculum reform. Innovation's respondents mentioned that the NIMS standards helped improve the curriculum and the facility. The NIMS recommendations for laboratory upgrades helped to convince the administration that the improvements were needed. However, respondents at Innovations were critical of the way the NIMS organization interacted with their program once they completed the curriculum reform process.

One of the criteria listed in the conceptual framework was the current state of curriculum development in the colleges. Both Traditions and Innovations produced rather extensive curriculum documentation. Much time had gone into the development of the program and the individual courses. Even though Traditions had not used the NIMS standards, many of the learning objectives were compatible with NIMS. Both schools also recognize student achievement to be a major issue in curriculum reform. Respondents realized that most students would not be able to demonstrate a mastery of the NIMS standards given the limited amount of coursework currently offered in the manufacturing specialties.

Respondents at both schools recognized that public relations and student recruitment play a larger role in the success of the manufacturing programs. Respondents at Innovations hoped that a NIMS accredited program would bolster a positive image in a program that has suffered from a great deal of negative publicity in the past several years. Respondents at Traditions believed that the low profile of NIMS among Michigan manufacturing companies is related to the minimal publicity associated with becoming NIMS accredited.

Finally, comments on future curriculum reform activities point out several differences between these two schools. Respondents at Traditions emphasize integration between related programs. They will continue to value the breadth of topics in the program versus the depth that NIMS encourages. Respondents at Traditions also expect that adding a new instructor will lead to a higher level of curriculum reform. The Innovations faculty members feel that their major curriculum reform task is behind them. They will be focusing on incremental changes and improvements. One Innovations instructor felt that the current challenges facing community college budgets and the rapidly changing manufacturing environment will shake out the weaker manufacturing programs in Michigan community colleges and strengthen those that remain.

Summary of research questions

The primary question in this study is: How, if at all, have the NIMS Metalworking Standards influenced manufacturing curriculum reform in the Michigan community colleges? Only 14% of the respondents are actively using NIMS. Several more are considering using NIMS in the curriculum. Based on these figures NIMS has not made significant progress in the Michigan community colleges. However, all of the colleges are aware of the NIMS standards, meaning that the standards did receive much publicity. If all of these schools have at least studied the NIMS standards and considered their potential use in curriculum reform the NIMS standards have influenced the curriculum to a small degree.

As a follow up to that first question a second question asked: Why NIMS has or has not had an effect on curriculum reform? No respondents in the survey or the site visits made the claim that NIMS was fundamentally wrong. All the respondents were familiar with the NIMS standards to the point of explaining why they did or did not choose to include the standards into the curriculum. The most common reasons against NIMS were a poor fit to the existing program goals, lack of industry support for NIMS, and the difficulty of adding additional components to an already crowded curriculum. The only negative comments about the NIMS standards involved some issues with the lab performance exercises. A few comments also mentioned the bureaucratic nature of the NIMS organization. Of the two institutions that did choose to fully implement the NIMS standards, the respondents simply indicated that the apparent benefits of a NIMS certified program outweighed the obstacles mentioned here.

CHAPTER 5

DISCUSSION AND CONCLUSION

When this study was first proposed, many Michigan community colleges were seriously pondering their future involvement with the NIMS standards. Several assumptions were made when the NIMS standards were introduced: the standards would be a good fit to existing community college programs, industry in the state was very supportive of the standards, and additional state funding would support NIMS related activities. Since then a noticeable shift has occurred regarding support of the NIMS standards. What began as a quiet whisper against the NIMS standards turned into a general agreement among Michigan community colleges that NIMS should not be the new standard driving manufacturing curriculum reform.

During the late 1990's, when the NIMS standards were finalized, manufacturing employment in Michigan was at an all-time high (MEDC, 1999). Because companies were competing for skilled workers, wages were being driven up. Employers felt that a large supply of well-trained workers would help them keep up with a surging demand for their products. The NIMS standards were seen by industry as a way to articulate their needs to local training and educational institutions. An unprecedented amount of government funding and private corporate resources were combined to launch the NIMS skills standards initiative.

At the same time many community college programs felt the pressure from local manufacturing companies to update their training programs and produce students who quickly become productive employees in a high-technology manufacturing environment (Salzman, 1998). Clear expectations of student performance were not apparent in most existing manufacturing curricula. The NIMS skills standards appeared to provide this missing link between what was taught in school and what was required in industry. To sweeten the pot, many new state grants and funding sources promised to direct funding towards programs that adopted the NIMS standards and built a curriculum incorporating the NIMS performance levels (Jacobs, 2001). Manufacturing programs appeared to be headed in the same direction as certificate programs such as automobile mechanics or nursing where all participants are held to a high national competency standard.

The results of this study show a disturbing disconnect between the intent of the NIMS skills standards and the direction of most curriculum reform and revision activity in Michigan community colleges. The remainder of this chapter attempts to answer the following questions: Have the NIMS standards failed to live up to their expectation in creating a common national skill standard? Have Michigan community colleges failed to reform their curriculum and meet the expectation of local employers to teach to a national standard?

The United States of America is comprised of diverse manufacturing regions. A common set of standards that applies to all types of manufacturing companies in all regions might be more idealistic than practical (Jacobs, 2001).

Although Michigan was listed as one of about a dozen states involved in this national skills standards initiative, other states played a greater role in this process. Michigan may have been on the fringe of this movement. Initial suggestions that state funding of occupational education might be linked to skills standards caused high initial interest in the NIMS standards. This funding link never materialized. One of the advocates of NIMS in the Michigan Department of Education moved to another state during this implementation process. No other individual continued the active promotion of NIMS.

During the late 1990's manufacturing companies had both the resources and the interest to pursue the skills standard initiatives. The recession beginning in 2000 greatly reduced the resources available to promote NIMS. A steady stream of displaced workers began to compete for whatever job openings remained (Right Place Program Manufacturer's Council, 2002). State budgets for curriculum development grants and program enhancements were reduced, putting the brakes on many NIMS related activities. Manufacturing programs in Michigan community colleges felt the effect of this downturn. Marginally successful programs during years of high employment and fully funded budgets were quickly reduced or eliminated. Student populations during economic downturns become more interested in traditional degrees that help them compete in a tight job market (Jacobs, 2001; Grubb, 1999).

Surprisingly, many Michigan manufacturing companies were not aware of the NIMS skills standards. If they did know about the standards they were not encouraging the local community colleges to re-align the curriculum with these skills standards. Many of the colleges in this study identified the lack of local industry support as a primary reason against using NIMS. Further attempts at integrating these skills standards were also discouraged by what some perceived as flaws in the “externally validated” projects included with NIMS. Unrealistic tolerances and poorly designed blueprints led instructors to believe that the materials were not adequately developed and tested.

Additionally, NIMS was trying to become financially self-sustaining by charging fees for many of the materials and certification activities. The initial fee for accrediting a program is $1500.00. This amount does not include the costs for potential facility improvements. Each instructor and student must pay a $40.00 registration fee, then a $35.00 fee for every certification test. Because of the many topic areas involved in the NIMS standards, the exam fees for students could soon exceed the cost of taking a community college class. Although Innovations Community College initially tried to offset the student costs of these certification exams, they had no long-term plan for funding these additional costs. Existing community college tuition and fee structures provide no easy means to support these additional program costs.

Another interesting perspective from industry emerged from this study. What exactly are most employers' expectations for community college manufacturing programs? According to one advisory board member, “Companies like to hire students who have had at least a year at the community college because they have some knowledge and also know whether they want to pursue the career”. In other words, employer expectations may be more realistic than some advocates for widespread change believe. If community colleges can give a student a good educational foundation along with some exposure to careers in manufacturing, the companies can build upon that foundation.

Michigan manufacturing companies have also shifted their training focus in the past decade. When the NIMS standards were being developed the emphasis was on "more" and "better". The manufacturing companies needed more employees to keep up with product demand, and they wanted better training in the traditional manufacturing skills. The NIMS standards focused on these issues. Since that time industry focus has shifted towards lean manufacturing principles with a higher emphasis on automation and technology. This new emphasis requires some skills not addressed by NIMS.

Finally, convincing arguments can be made for the NIMS standard in guiding a training program designed to place skilled employees on the shop floor. At the community college level, however, classes are often filled with a variety of students. One group intends to transfer to a four-year program. Others are taking the course as a "service course" – such as a tool design major who takes a machining course. Additionally, community colleges provide an environment for students to explore potential career choices. Faced with this variety of students in one classroom, instructors are not encouraged to create a job-training type of learning environment. Stiehl and Lewchuk (2002) suggest that community colleges should look beyond the competency framework of skills standards towards the outcomes framework of curricular development. The outcomes framework emphasizes the ability to synthesize program content to solve complex problems typical of what students will face in the workplace.

In addition to exploring the influence of the NIMS skills standards on Michigan community college curriculum, this study examined the additional driving forces behind curriculum development and maintenance – administration, advisory board, and faculty. Comments from the survey and additional conversations during the site visits helped to clarify the roles of these three groups.

The college administration strongly influences the process of curriculum reform. First, high expectations can be communicated to faculty and staff regarding the need for well-designed curriculum with clearly stated goals and objectives. Second, an institutional culture may be cultivated where curriculum development is supported and encouraged (Perin, 2000). This support could include faculty release time, seminar and professional development activities, opportunities for shared curriculum ventures, and staff support for instructional design. Finally, the reward structure in community colleges could better encourage curriculum development activities. Because pay is often related to instructional hours, community college instructors might take on more teaching responsibilities and cut back on related work such as curriculum development (Grubb and Associates, 1999). Administrators must also consider how the reliance on more part-time and temporary instructors will affect program and course development.

This study also explored the complex relationship of advisory committee and local industry involvement with community college manufacturing programs and curriculum. Survey respondents from the colleges expressed appreciation for the time and effort expended from these local industry groups. Equipment and materials donations have helped defray the high costs of running the programs. Local companies provide internship opportunities and hire program graduates to help support the college. At the same time, respondents referred to the process of working with advisory committees as "emotionally draining" and "a necessary evil".

Also mentioned was the direct influence of local industry owners on the decisions of community college administrators. Much of the literature describes the highly political nature of community college leadership (Bailey and Morest, 2004; Salzman, 1998; Jacobs, 2001). Interviews with administrators confirmed that community college leaders are willing to listen to prominent business leaders and industry groups that may have influence over public funding issues and be able to direct training revenue related to the college. However, both community college staff and advisory board members acknowledged some suspicion about each other's real motives in this relationship. One community college representative mentioned that local companies have selfish ambitions for obtaining trained employees rather than well-educated graduates. College instructors wonder whether industry representatives understand curriculum issues. Those who work in industry question whether the college staff understand the needs of modern manufacturing companies and have the commitment to make substantial program changes. Both sides admit that the attempt to involve local industry in program and curriculum issues remains rather political.

One final observation is that responsibilities of curriculum reform remain largely in the hands of the community college instructor. Although the many factors already discussed – administrative support, institutional resources, national standards, and local industry involvement – all influence the vitality of a program, the job of revising curriculum is primarily left to the instructors. Perin (2000) identifies a faculty leader as a primary ingredient of curriculum reform. Following are several observations regarding the manufacturing instructors included in this study:

- Professionalism. Some instructors view themselves as true manufacturing professionals. They have built careers in manufacturing, are actively involved in professional societies, maintain close ties with manufacturing companies, and are well respected in their specific fields.
- Program Builders. Several instructors surveyed are passionate about building and maintaining their manufacturing programs. They have ideas for public relations, recruitment, retention, and student transfer opportunities. They build up their labs and impress visitors with a clean and organized facility.
- Commitment. Curriculum development is normally done "after hours". It takes a back seat to the pressing issues of teaching load and classroom activities. Some instructors are willing to devote blocks of time in the summer or during breaks to ensure that this work is accomplished.

- Sense of Urgency. A few of the instructors indicated a sense of urgency in the need to reform the manufacturing curriculum. They feel that Michigan has reached a critical stage in its ability to compete on a national and international level. They feel that our community colleges can play a major role in this effort.

Unfortunately, not all community college instructors fit into the above categories. Some are nearing retirement, others will only perform the minimum requirements of their faculty contracts, and still others feel that they have job security regardless of the direction of their program. One administrator described the hiring process of a community college instructor as a "million dollar" decision. Over a period of ten years the college will likely invest a million dollars into salary, benefits, training, and professional development of an instructor. The return on investment varies greatly among faculty. Another administrator described the faculty work environment in higher education as "one large volunteer organization". Tenured faculty can rarely be forced to do anything.

An additional restraint on manufacturing curriculum reform is the small program size typical in most Michigan community colleges. Some manufacturing courses are taught by instructors from other departments, while other full time manufacturing instructors also teach courses in other departments. Adjunct instructors are teaching a higher percentage of the courses, which means that the few full time faculty left in the manufacturing departments have many responsibilities to maintain the program. Finding additional time to revise the curriculum will likely remain a challenge.

The literature reviewed in this study also contrasted the lofty goals of curriculum reform with the reality of the community college student population. Brewer (2000) points out the need for renewed emphasis on basic skill training and remedial skills. Grubb and Associates (1999) identify the ways community college instructors cope with academically unprepared students – "accommodation" or "blissful indifference". Jacobs (2001) explains how the "vocational" tracks that provided terminal job training programs in community colleges are now coming under fire. New curriculum reform activities must accommodate students at their various levels of academic achievement.

In summary, this study shows that the NIMS skills standards have had minimal effect on the Michigan community college manufacturing curriculum. Original expectations were that these standards would help to create a common curriculum upon which industry and education could agree. With only 2 of 14 colleges adopting the NIMS standards and only a few more seriously considering them, it appears NIMS will not be a common standard in the manufacturing programs. Several respondents of the study felt from the beginning that the NIMS standards were not a good fit with higher education. Others believed that the NIMS organization fell short on delivering a workable set of standards that could be incorporated into an existing curriculum. However, there was general agreement that the NIMS standards will continue to be an important benchmark for manufacturing programs.

Other effects on curriculum reform were also investigated. The faculty, administration, and advisory committee were identified as three primary forces.

The tension between these groups provides a reasonable amount of balance to the programs, but also creates obstacles for rapid change in the curriculum. Several faculty in this study felt that they had successfully "weathered another small storm" in the larger perspective of new community college initiatives and reforms.

This study helps us to see that although there is room for curriculum improvement in Michigan community college manufacturing programs, curriculum reform is already taking place in most colleges. Many factors affect curriculum reform. The efforts of the individual instructor seem to be the largest factor in the success of the process. Curriculum reform will continue to take place on a regular basis. The NIMS standards will likely remain a viable component of a focused job skills training program offered in a career center, community college certificate program, or a private job training center. It does not appear that NIMS skill standards will become a driving force in the manufacturing programs at Michigan community colleges.

APPENDIX A

Directory of Michigan Community Colleges

College 2001/2002 Program Enrollment	**Occupational Contacts**	**Program Inventory** CIP code, program, yrs. to complete	**Instructors**
Alpena Community College 666 Johnson St. Alpena, MI 49707-1495 989-356-9021 www.alpenacc.edu 2776 students	Dr. Mary Ann Carlson V.P. for Academic Affairs 989-358-7233 carlsonm@alpenacc.edu Charles N. Wiesen wiesenc@alpena.cc.mi.us	15.0603 Manufacturing Technology 1,2 48.0506 Apprentice – Millwright 1 notes: NIMS certified but might not re-certify 3 full time instructors shared between apprentice, CAD, math, and manufacturing	Jeff Monroe 989-358-7258 Monroej@alpenacc.edu Robert Tosch 989-358-7421 toschr@alpenacc.edu Tim Ratz 989-358-7268 ratzt@alpenacc.edu
Bay de Noc Community College 2001 North Lincoln Rd. Escanaba, MI 49829-2511 906-786-5802 www.baydenoc.cc.mi.us 2500 students	Patricia Valensky V.P. Instruction / Student Learning 906-786-5802 valenskp@baydenoc.cc.mi.us Dean Masters mastersd@baydenoc.cc.mi.us	15.0303 Automation Technology 2 15.0603 Manufacturing Technology 2 48.0503 Industrial Mach. Tech. / Numerical Control 1, 2 Notes: Mfg. Tech. program has been eliminated	Jerry Havill (CAD/drafting) John Soltis - machine tool Soltisj@baydenoc.cc.mi.us 906-786-5802 Mark Highum – Automation
Delta College 1961 Delta Rd. University Center, MI 48710 989-686-9000 www.delta.edu 10,500 students	David M. Bledsoe Asc. Dean of Career and Continuing Education Programs 989-686-9133 dmbledso@alpha.delta.edu Brian McInerney	15.0603 Manufacturing Technology 2 52.203 Lean Manufacturing 1 The following programs have been inactivated: 48.0503 Machine Tool Operations 1, 2 48.0599 CNC Technology 2 Notes: 5 full time and 3 part time instructors	Christine Eckerle Cmeckel@alpha.delta.edu Chairperson for Mfg. Tech. Rod Mueller Rlmuelle@alpha.delta.edu Machine tool instructor Russ Davis rwdavis@alpha.delta.edu Skilled trades

* Glen Oaks Community College 62249 Shimmel Rd. Centreville, MI 49032-9719 269-467-9945 888-994-7818 www.glenoaks.cc.mi.us 1152 students	Dr. Dennis P. McCarthy Executive Director of College Development 269-467-9945 dmccarthy@glenoaks.cc.mi.us	48.0501 Machine Tool Technology 1 notes: no full time instructor	Jim Romain Part time
* Gogebic Community College E-4946 Jackson Rd. Ironwood, MI 49938 906-932-4231 www.gogebic.edu 933 students	James A. Lorenson Dean of Instruction 906-932-4231 jiml@admin.gogebic.edu	15.0603 Manufacturing Technology 2 notes: program is currently being phased out – some of these classes will be offered to CAD students	Connie Hicks Connie.hicks@faculty.gogebic.edu
Grand Rapids Community College 151 Fountain St NE Grand Rapids, MI 49503-3295 616-234-3600 www.grcc.edu 13,741 students	John McGrail Assistant Dean 616-234-3600 jmcgrail@grcc.edu	47.0303 Industrial Maintenance 2 48.0503 Tooling and Manufacturing Technology 2 notes: 2 full time instructors, 3 part time	Tom Boersma 616-234-3613 tboersma@grcc.edu Mark Saur
Henry Ford Community College 5105 Evergreen Dearborn, MI 48128-1495 313-845-9609 www.henryford.cc.mi.us 12,000 students	Dr. Jo-Ann Terry V.P. / Dean Career Education 313-845-9607 jterry@hfcc.net Robert Morris rmorrish@hfcc.net	15.0405 Automation and Robotics 2 15.0603 Manufacturing Trades 2 15.0699 Computer Numerical Control 1 47.0303 Plant Maintenance Trades 2 48.0503 Machinist 1 48.0507 Tool and Die Maker 1 notes: 1 full time, 3-5 adjunct	Ken Wright Kwright@hfcc.net 313-845-6331 Notes: Ken Wright is working with Michigan Haas Technical Education council to develop a CNC specialist certificate

* Jackson Community College 2111 Emmons Rd Jackson, MI 49201 517-796-8615 www.jccmi.edu 5092 students	Joyce Lockman Dean of Academic Outreach 517-796-8502 joyce_lockman@jccmi.edu Pene Vandenburgh Assistant Dean Pene_vandenburgh@jccmi.edu	48.0501 Manufacturing Technology 2 48.0503 Machinist 1 48.9999 Precision Production 2 These programs are being discontinued due to large budget cuts and some decline in enrollment. This will be re-visited after a millage vote and further discussions with manufacturers.	Eric Ollila 517-796-8528 eric_ollila@jackson.cc.mi.us Steve Brennen
Kalamazoo Valley Community College 6767 West O Ave. P.O. Box 4070 Kalamazoo, MI 49003-4070 269-488-4400 www.kvcc.edu 6391 students	Richard F. Roder Dean of Applied Technology 269-488-4219 droder@kvcc.edu	48.0503 Machine Tool Automation 2 Machine Tool Technology Notes: 1 full time 7 part time 1 full time adjunct	Howard Carpenter hcarpenter@kvcc.edu Will Oas
Kellogg Community College 450 North Ave. Battle Creek, MI 49017-3397 Kellogg C. C. RMTC 405 Hill Brady Rd. Battle Creek, MI 49015 259-965-4137 www.kellogg.edu 5539 students	Charles Parker Dean of Career and Occupational Education 259-965-3931 parkerc@kellogg.edu Bill Baker baker@kellogg.cc.mi.us	15.0403 Production Technology 2 48.0503 Industrial Machine Tool 2 Notes: 1 full time, 2 part time They also offer internet modules in machining and tool + die	Tom Longman longmant@kellogg.edu 259-965-4137
Kirtland Community College 10775 North St. Helen Road Roscommon, MI 48653 989-275-5121 www.kirtland.edu 1567 students	Kathy Marsh Associate Dean 989-275-5000 marshk@kirtland.edu Doty Latuszek Associate Dean latuszed@kirtland.edu	15.0603 Manufacturing Process Technology 2 47.0303 Industrial Maintenance 2 48.0501 Machine Tool Technology 2 notes: One full time instructor. They did not have a good experience with NIMS, many promises made by NIMS but no follow through. Program is changing to OE/OE format.	Leonard Miller 989-275-5121 x 358 517-275-8143 millerl@kirtland.edu .

Lake Michigan College 2755 East Napier Avenue Benton Harbor, MI 49022-1899 800-252-1562 Bertrand Crossings Campus 1905 Foundation Drive Niles, MI 49120 616-695-1391 www.lakemichigancollege.edu 3796 students	Robert Harrison Dean of Occupational Studies and Business Services 269-926-4086 harrison@lakemichigancollege.e du	15.0403 Industrial Maintenance 1 48.0501 Machine Tool Technology 2 48.9999 Skilled Trades Technology 2 Notes: 1 full time instructor, several adjunct	Wayne Borr Director, Apprentice Training 269-926-2136 borr@lakemichigancollege.edu Marty Warner warner@lakemichigancollege.edu 269-926-4490 Ken Flowers flowers@lakemichigancollege.edu 269-927-8100 x 3032
Lansing Community College 528 N. Capitol Ave. P.O. Box 40010 Lansing, MI 48910 800-644-4522 517-483-1364 www.lcc.edu 13,989 students	James Predko Interim Dean, Careers Div. 517-483-1320 jpredko@jcc.edu	15.0603 Industrial Technology 2 15.9999 CNC Programming 2 48.0501 Machinist Toolmaker 2 52.0205 Supervision, Manufacturing 2 Notes: 2 full time instructors 2 part time	Clint Jones cjones@lcc.edu 517-483-1390 Fritz Smydra 517-483-1364 fsmydra@lcc.edu John Theroux
Macomb Community College 14500 East Twelve Mile Rd. Warren, MI 48088 586-445-7519 www.macomb.edu 12,775 students	Dr. Roberta Jackson Vice Provost, Career Programs 586-445-7640 jacksonr@macomb.edu Jim Sawyer, Dean sawyerj@macomb.edu	15.0403 CNC Computer Programming 2 15.0603 Manufacturing Technology 2 48.0503 Model / Pattern Making 1 Notes: 1 full time 3 part time	Mark Saglimbene 586-445-7149 saglimbenem@macomb.edu
Mid Michigan Community College 1375 South Clare Ave. Harrison, MI 48625 989-386-6622 www.midmich.edu 2775 students	Beth Sendre Interim Dean of Occupational Studies 989-386-6642 bsendre@midmich.edu	48.0501 Machine Tool Technology 2 48.0503 Operator Assistant 1 Notes: 1 full time, 1 part time	Eric Sander CAD / Machine Tool 989-386-6676 esander@midmich.edu

Monroe Community College 1555 South Rasinville Road Monroe, MI 48161 734-384-4209 www.monroecc.edu 3757 students	Patrick J. Nedry Director of Occupational Programs 734-384-4209 pnedry@monroeccc.edu	15.0603 Manufacturing Technology 2 15.0805 Metrology Technology 2 Notes: 2 full time, 3 part time	Mike Mohn mmohn@monroeccc.edu Bob Leonard bleonard@monroeccc.edu Gary Dewitt gdewitt@monroecc.edu 734-292-3722
* Montcalm Community College 2800 College Dr. Sidney, MI 48885 989-328-2111 www.montcalm.edu 1963 students	Jean Bailey Assoc. Dean of Academic Services 989-328-1234 jeanb@montcalm.edu Dan Herman dannyh@montcalm.edu	15.0603 Industrial Technology 2 48.0503 Machine Tool Operation 1 Notes: 1 full time 3 part time	Gary Warner
Mott Community College 1401 East Court St. Flint, MI 48503 810-762-0384 www.mcc.edu 7955 students	Michael Benner Asc. Dean of Technology 810-762-0500 mbenner@mcc.edu	47.0102 Machine Repair A.R.I. 1 47.0303 Millwright A.R.I. 1 48.0501 Metal Pattern Making A.R.I. 1 48.0503 Metal Machine Working Operator 1 48.0507 Tool and Die Making A.R.I. 1 48.9999 Industrial Technology 2	Jessie McKelry jmckelry@mcc.edu 810-232-3676 Michael Persich 810-762-0385
Muskegon Community College 221 South Quarterline Road Muskegon, MI 49442 231-777-0367 www.muskegon.cc.mi.us 4817 students	Robert C. Ferrentino Dean of Occupational Programs 231-777-0427 ferrenb@muskegoncc.edu	15.0603 Industrial Technology 2 48.0501 Machining Technology 2 notes: 1 full time 2 - 3 part time	Lee Kleinheksel 231-777-0219 kleinhl@muskegon.cc.mi.us

Northwestern Michigan College 1701 East Front St. Traverse City, MI 49686 231-995-1000 800-748-0566 www.nmc.edu 4810 students	Karen Howie Director, Center for Instructional Excellence 231-995-1170 khowie@nmc.edu	15.0603 Manufacturing Technology 2 48.0503 Machine Tool Operator 1 Notes: 1 full time and 1 part time	Ray Niergarth 231-995-1310 rniergarth@nmc.edu
Oakland Community College 2900 Featherstone Rd. Auburn Hills, MI 48326 248-232-4100 Orchard Ridge Campus 27055 Orchard Lake Rd. Farmington Hills, MI 48334 248 522-3710 www.oaklandcc.edu 25,126 students	Dr. Sharon Blackman President 248-232-4050 slblackm@oaklandcc.edu Mr. Phillip Hale Dean of Applied Technology 248-232-4312 prhale@oaklandcc.edu	15.0603 Tool Machinist 2 15.0603 Manufacturing Technology 2 15.0603 Multi-Skilled Manufacturing Tech. 3 48.0501 Machine Tool Technology 2 48.0599 MTT: Numerical Control 2 Notes: 1 full time, 1 part time	Michael Clancy 248-232-4505 mlclancy@oaklandcc.edu multi-skilled manufacturing Steve Atma satma@oaklandcc.edu machining
* St. Clair Co. Community College 323 Erie St. P.O. Box 5015 Port Huron, MI 48061-5015 810-984-3881 www.sc4.edu 6047 students	Dr. Carol Nowakowski Dean of Students and Instructional Support Services 810-989-5561 cnowakowski@sc4.edu	15.0603 Manufacturing Technology 2	Karen Thrift kthrift@stclair.cc.mi.us 810-989-5626 Don Reuba Industrial Automation
* Schoolcraft College 18600 Haggerty Rd. Livonia, MI 48152-2696 734-462-4457 www.schoolcraft.edu 12,830 students	Denise Sigworth Dean of Instruction 734-462-4454 dsigwort@schoolcraft.edu Bruce Sweet Asc. Dean	15.0603 Computer Integrated Manufacturing 2 Notes: No full time faculty in this department. Full time faculty from other programs teach in manufacturing along with 1-2 part time	Chuck Gibbons Materials Science 734-462-1458

Southwestern Michigan College 58900 Cherry Grove Rd. Dowagiac, MI 49047-9793 616-782-1260 800-456-8675 www.swmich.edu 3120 students	Tom Buszek Dean of Advanced Manufacturing Technologies 269-687-5641 tbuszek@swmich.edu	47.9999 Industrial Maintenance Technician 2 48.0503 Machine Tool Technology 2 48.9999 Precision Production 2 notes: programs are down in numbers, may need more flexibility and modules? 1 full time, 1 part time	Duane Hall Larry Westgate 269-687-4814 lwestgat@smc.cc.mi.us
Washtenaw Community College 4800 East Huron River Dr. Box D-1 Ann Arbor, MI 48106-0978 734-973-3497 www.washtenaw.cc.mi.us 12,950 students	Rosemary Birkel Wilson Dean of Business and Computer Technologies 734-973-3724 wilbur@wccnet.org Les Pierce lpierce@wccnet.org	48.0501 Machine Tool Technology 2 48.0501 Numerical Control Programming 2	Tom Penird tpenird@wccnet.org Machine Tool Gary Schultz 734-973-3317 gschultz@wccnet.org James Teevens 973-3726
* Wayne County Community College 21000 Northline Taylor, MI 48180 734-374-3204 www.wccc.edu 11,660 students	Dr. Mary M. Smith Vice Chancellor – Workforce Development 313-496-2587 msmith1@wccc.edu Rahmattollah Golshan Department head	48.0507 Machine Tool Technology 2	Jack Dudde 734-728-2872 jeurka@aol.com
* West Shore Community College 3000 North Stiles Rd. Box 277 Scottville, MI 49454 231- 845-6211 www.westshore.edu 1233 students	Gerald Svendor V. P. Workforce Development 231-845-6211 gesvendor@westshore.cc.mi.us	48.0503 Machine Tool Technology 2 notes: program used as high school facility during the day, adjunct instructor at night	Ross Kissel (administrator)

Table 9: Census of Michigan Community Colleges

APPENDIX B

Manufacturing Curriculum Survey
Explanation and Instructions

This 3-page document includes: *page 1 – explanation and instructions*
page 2 – consent form
page 3 – survey

This survey is an attempt to investigate the current state of curriculum reform and skills standards in the manufacturing programs of the 28 Michigan community colleges. The following descriptions are given in an attempt to clarify the survey questions and the terms used in this survey.

Manufacturing / Machining Curriculum

A recent search through the Michigan Community College Dean's Curriculum Guide revealed at least one machining / manufacturing program on the books at each of the 28 community colleges. All 28 community colleges have a machining lab facility and have, in the recent past, offered classes in machine tool related topics. Sometimes referred to as the "Machine Tool" program, these programs actually appear under a variety of names and descriptions. The following program names and CIP codes appeared most often:

CIP code	*Program Name*	*Number of schools*
15.0603	Manufacturing Technology	15
48.0503	Industrial Machine / CNC Technology	13
48.0501	Machine Tool Technology	13

A lesser number of schools used other program names and CIP codes to describe programs in the manufacturing / machining fields. Obviously, most schools listed multiple programs in this category. In response to this survey, please address the curriculum that you feel best fits under the above program names.

Curriculum

The meaning of the term "curriculum" can vary greatly among community college constituents. For the purpose of this study we will define curriculum as an "academic plan ... including purposes, activities, and ways of measuring success" (Stark and Lattuca, 1996). This will include the following elements: purpose, content, sequence, learners, instructional processes, instructional resources, evaluation, and adjustment.

Respondents

This survey is directed towards community college instructors whose primary teaching loads are assigned in the machining / manufacturing programs. This survey is being sent to the schools that currently appear to have an active machining / manufacturing program.

Consent Form

The Impact of Skills Standards on Community College Manufacturing Curriculum

This study will begin with a brief survey of a lead instructor at the community colleges with manufacturing programs. I expect this to include about 18 of the original 28 community colleges. This survey will attempt to gain information about manufacturing curriculum reform and the affects of the NIMS (National Institute of Metalworking Skills) standards on the curriculum. Following that survey, two colleges will be chosen for case studies. The case studies will include a site visit to see the manufacturing facilities, interviews with several persons at each site, and a review of the manufacturing curriculum.

The total amount of time required for your participation in this study is estimated to be between 20 to 40 minutes. Participation in this study is voluntary. Specific questions may be skipped or you may terminate your participation without penalty.

This study is designed to ensure confidentiality of the information you supply. Confidentiality in this case means that only the researcher will be able to identify the source of the data. The source will not be revealed in the publication of the data. Your privacy will be protected to the maximum extent allowable by law.

If you have any questions about this study, please contact:
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If you have questions or concerns regarding your rights as a study participant, or are dissatisfied at any time with any aspect of this study, you may contact – anonymously if you wish: Ashir Kumar, M.D., Chair of the University Committee on Research Involving Human Subjects (UCRIHS) by phone: (517) 355-2180, fax: (517) 432-4503, e-mail: ucrihs@msu.edu, or regular mail: 202 Olds Hall, East Lansing, MI 48824

I voluntarily agree to participate in this study.

________________________ ________
(signature) (date)

( ) Please check this box if you are a minor.

____
(parent or guardian signature)

UCRIHS APPROVAL FOR THIS project EXPIRES:

APR 3 0 2004

SUBMIT RENEWAL APPLICATION ONE MONTH PRIOR TO ABOVE DATE TO CONTINUE

Manufacturing Curriculum Survey

Please review the information in the consent form included with this survey.
By completing the survey your signature on the consent form is implied.

1. When was your last major curriculum revision in your current program? Year ___

   Comments:

2. Is your curriculum generally understood and followed by those teaching in your department?

   Yes ___ No ___ Unsure ___

   Comments:

3. Do you use lab performance-based student assessments?

   Yes ___ No ___ Unsure ___

   Comments:

4. If you use performance-based student assessments, are they externally validated?

   Yes ___ No ___ Unsure ___

   Comments:

5. Are you aware of the NIMS metal working standards?

   Yes ___ No ___ Unsure ___

   Comments:

6. Are the NIMS standards currently used to focus the direction of your program?

   Yes ___ No ___ Unsure ___

   Comments:

7. If you do not currently use the NIMS standards in your curriculum, do you plan to in the future?

   Yes ___ No ___ Unsure ___

   Comments:

8. When do you anticipate your next re-write / revision of your curriculum? Year ___

   Comments:

9. Does your administration actively encourage an updated and cohesive curriculum in your department?

   Yes ___ No ___ Unsure ___

   Comments:

10. Do you feel that your advisory committee / local employers have an active voice in your curriculum decisions?

    Yes ___ No ___ Unsure ___

    Comments:

APPENDIX C

Results of Manufacturing Curriculum Survey

1. When was your last major curriculum revision in your current program? Year ___

   1996 n=1
   1997 n=1
   1998 n=1
   2001 n=4
   2002 n=2
   2003 n=5

   Comments:
   Developed several certificate programs and 3 new courses in 2003.
   Changed general education requirements in 2001.
   Our curriculum is continuously being updated.
   NIMS certified in 2002.
   In 1996 we implemented open lab, self-directed format (minimal lecture), then in 2003 returned to structured lab times with self-directed study.

2. Is your curriculum generally understood and followed by those teaching in your department?

   Yes=13 No=0 Unsure=1

   Comments:
   Small department.
   Adjunct instructors often have little guidance on what to teach.

3. Do you use lab performance-based student assessments?

   Yes=14 No=0 Unsure=0

   Comments:
   Lab projects

4. If you use performance-based student assessments, are they externally validated?

   Yes=1 No=13 Unsure=0

   Comments:
   The NIMS projects are externally validated.

5. Are you aware of the NIMS metal working standards?

   Yes=14 No=0 Unsure=0

   Comments:
   Instructor is NIMS certified.

6. Are the NIMS standards currently used to focus the direction of your program?

   Yes=2 No=12 Unsure=0

   Comments:
   We use NIMS where it fits into our program, but there are significant opportunities for improvements in the NIMS process. We determine the direction of our program, the NIMS projects that meet our standards are used.

The NIMS standards are more suited to training those who will go directly into a machining career versus transfer students who are taking these courses for background knowledge.

7. If you do not currently use the NIMS standards in your curriculum, do you plan to in the future?

Yes=3 No=7 Unsure=4

Comments:

We currently use the NIMS standards

Local industry has not placed any importance on NIMS.

Possibly

Initially decided yes, then after further study decided no.

8. When do you anticipate your next re-write / revision of your curriculum?

2004 n=7
2005 n=3
2007 n=1
2008 n=1
? n=2

Comments:

As needed our program and instructors are committed to continuous quality improvement as applied to our lab equipment, supplies, and course content with a three-year forecast for most major program changes, though this may occur on an informal basis. Within the next 12 months we will be making a revision to our curriculum.

Currently in process of developing several more certificate programs.

Instructor is retiring and program is going to open entry / exit format with part time instructor.

Basic machining content does not change. Format and delivery methods change with the latest "hot topic".

Each year minor changes.

If I am still around, may retire soon

9. Does your administration actively encourage an updated and cohesive curriculum in your department?

Yes=11 No=1 Unsure=2

Comments:

Since we (faculty) determine the direction of our curriculum administration has never had to address this issue. Also we have a new vice president and she has not expressed an interest in getting involved in our program.

Purchased new machinery, approved curriculum changes, etc.

10. Do you feel that your advisory committee / local employers have an active voice in your curriculum decisions?

Yes=10 No=3 Unsure=1

Comments:

Our curriculum is a dynamic and flexible training system, improving daily, always adjusting to industry trends and student needs. This happens through feedback from employers, past students, and changing technology. However, very few local employers have taken the opportunity to get actively involved in the direction of our program.

Program was recently changed without advisory committee input.

Advisory committees are not real vocal about curriculum issues.
All major decisions must be approved by advisory committee.
Advisory committee decided against NIMS.

APPENDIX D

Site Visit Protocol

1. At the beginning of the site visit I will introduce myself to the lead instructor and attempt to establish a cordial relationship. We will try to negotiate a schedule for the day so that I can observe and interview others in a manner that will not distract them from their regularly scheduled activities.
2. I will present the lead instructor with a copy of the census and survey results as a starting point for further conversation. I will request written copies of the existing curriculum for further review.
3. No recording devices will be used, and assurance will be given regarding confidentiality of data. I will rely on interview notes and formally write up the interview results the same day of the interviews.
4. Each interview will follow a printed interview guide that will be given to each participant at the beginning of each interview. The interview guide will contain a brief statement summarizing the purpose of the study. Each participant will also be given a copy of the UCRIHS consent form.
5. Follow-up notes will be sent out, when possible, to thank each participant for his/her time.

Contact Summary Sheet

Name: ________________ Date: ________

___ Full time faculty
___ Part time faculty
___ Administrator
___ Advisory board member
___ Student

☐ Consent form

Brief description of study:
This is a study about manufacturing curriculum in Michigan community colleges. The questions are designed to obtain qualitative information regarding the importance of developing and maintaining a curriculum that will prepare students for further education and for working in today's challenging manufacturing environment.

Topics of discussion will include:

- brief overview of the study, census and survey information
- administrative support of program and curriculum development
- faculty time and resources spent on curricular issues
- local industry support for curriculum development activities
- perceptions of recent manufacturing curriculum revisions
  - factors influencing curriculum revision
  - reasons for or against using NIMS to drive curriculum revision
  - future plans for manufacturing programs and curriculum

APPENDIX E

Cross-site Analysis for Case Studies

In this portion of the study I display the qualitative data in a cross-site analysis. The data are coded into seven topics, with each topic box comparing data between the two sites. The data are labeled with the source of information: "adm" for administrators, "adv" for advisory board members, and "ins" for instructors.

	Administrative support of program and curriculum development
Traditions	Ins: Supports with both resources and encouragement, but expects a good job. Ins: Currently good cooperation and support for programs Adm: Very supportive but expects faculty to do most curriculum development on their own time (summer and break).
Innovations	Ins: Administration should be more specific about goals and targets. Ins: Old administration was very supportive, new administration? Ins: Administration does not know how to react to some current bad publicity about manufacturing; tight financing puts a squeeze on expensive programs. Adm: The program needs to stand on its own. Adv: Support is declining under new administration

	Faculty time and resources spent on curricular issues
Traditions	Ins: Semesters are very busy with teaching activities, don't want to spend weekends working on curriculum, summer seems to be the best time. Ins: Appreciates days given during the semester for seminars, in-service, etc. This is more focused time for curriculum work. Adm: During the school year it is very busy, summer is a better time, instructors should network on curriculum issues.
Innovations	Ins: Tries to spend about 1 hr. per week on curriculum and spend extra time in the summer. Ins: Self described workaholic, spends a lot of time during the summer working on curriculum issues. Ins: Instructors are expected to do it on their own. Not much compensation time or administrative help given. Adm: If necessary grant money could help support these efforts.

	Local industry support for curriculum development activities
Traditions	Ins: Some specific classes have been developed to meet local needs, advisory committee is not always available for help and some instructors do not feel that the advisory committee is very effective. Ins: Cooperation with local industry can be challenging, the

	advisory committee must be better promoted and given more opportunity for input. Adm: The curriculum is influenced by local industry and special processes are taught as a result but advisory committee role could be stronger. Adv: Industry people are busy but are willing to serve as long as it is not just a political event where the group socializes and rubber stamps the program.
Innovations	Ins: Local support is improving; better recruitment strategies by companies would help the college focus the curriculum on those needs. Ins: Local support is pretty good but some employers focus mostly on their own needs, not the long-term needs of the student. Ins: College also encourages students to look beyond local opportunities. Adv: Local industry does support the program. Adm: Competitive companies are training driven, they should help encourage community colleges to help develop effective training programs.

	Perceptions of recent manufacturing curriculum revisions
Traditions	Ins: Have resulted in more class offerings with fewer students, causing merged or cancelled class sections. Ins: Curriculum reform has been a group effort with generally good results.

	Adm: We have a solid program with a strong base. We don't jump quickly into new areas but need to embrace more new technology Adv: The advisory committee has given input on new machine tools and processes.
Innovations	Ins: The curriculum has become much more organized and easier to use – 3 ring binders for each class, power point presentations for each topic. Ins: NIMS was good because it helped upgrade the manufacturing labs and re-focus the curriculum. Ins: Learned to stay away from OE/OE format, curriculum is now better aligned for transfer to 4-year colleges. Adv: Moving in the right direction. Adm: Hard to keep up with new processes and better ways of doing things.

	Factors influencing curriculum revision
Traditions	Ins: New technology, trends in industry, administrative ideas all help drive curriculum reform. Ins: The need to challenge a wide range of students must always be considered. Adm: New technology and local industry change will drive new curriculum. Adv: Advisory committee will continue to push curriculum revisions.

Innovations	Ins: Need for continuous improvement in small increments. Keep trying new things to raise the standard. Ins: Must constantly upgrade because of changes in industry. Some type of certifiable standard (other than NIMS) would be nice Adv: Meeting a wide variety of needs. Adm: Must find out employers needs, experiment with training to those needs, and then mainstream the good ideas.

	Reasons for or against using NIMS to drive curriculum revision
Traditions	Ins: NIMS is not a good fit for community college curriculum but it is a helpful standard for curriculum reform. Adm: NIMS did not fit the mission of the community college, no driving force to use the standards. Adv: NIMS is good but very bureaucratic and expensive.
Innovations	Ins: The NIMS material is not that good. The NIMS organization performed a poor execution of the program in Michigan and no local support exists. Ins: The college will probably not continue to pay the costs associated with NIMS. They will continue to use only selected portions of the NIMS material. Adv: NIMS is not widely supported in local companies

	Future plans for manufacturing programs and curriculum
Traditions	Ins: More integration between programs Ins: Need to do better marketing and public relations for the program, more visibility. Adm: It is time to take the program to a new level, more integration with other programs in the college.
Innovations	Ins: Wants to keep working with companies to make sure curriculum has the right focus, might consider alternative accreditation / certification opportunities. Ins: Will continue to try new things and focus on recruitment to keep program strong. Ins: Community college programs are more important than ever to local employers. Continue to emphasize good basic skill training. This economic cycle will likely shake out several weak manufacturing programs in the state, hopefully the remaining ones will get stronger. Adm: Colleges need to keep looking ahead to see what will be relevant. Good faculty rotation is important to keep new ideas going.

Table 10: Cross-site Analysis for Case Studies

APPENDIX F

The National Institute of Metalworking Skills

A brief overview of NIMS and a detailed explanation of the skills standards

(This information was mostly obtained from the NIMS web site: http://www.nims-skills.org)

1. Background

In late fall of 1992, the U.S. Departments of Education and Labor launched an initiative to fund industry organizations and consortia to develop national occupational skill standards for their industries. Skill standards refer to the major duties, knowledge, and skills that define the performance requirements and expectations in the modern workplace. The national basis of these standards refers to the process followed in their development, namely that they be reviewed and reflect employer and employee opinions in the nationwide distribution of the industry. The skill standards, once established, are intended to guide workforce development programs in the public and private sectors in building a world-class workforce in the United States.

The National Tooling and Machining Association (NTMA) was selected to work with other leading organizations in the metalworking industry to establish national skill standards for metalworking occupations. This effort is developing standards with input from workers, employers, trainers, and educators nationwide. The standards are being benchmarked to those in Germany, Japan, and other leading metalworking countries.

The standards are proposed for broad application in all public and private workforce development programs that prepare youth and adults for employment in the metalworking industry. They also are intended for application in upgrading programs, retraining programs, and apprenticeships for workers already employed by metalworking companies.

Seven other trade associations and three organized labor institutions have joined NTMA in this skill standards development effort. These associations work cooperatively through the National Institute for Metalworking Skills, Inc. to guide the establishment of national standards for the industry. Major responsibilities of the Institute include:

• developing recognized occupations organized into career paths within the industry;
• writing and verifying skill standards for each recognized career path;
• providing for the assessment and credentialing of workers;
• certifying of training programs that train to the industry's skill standards.

The Council of Great Lakes Governors also is participating. The Council and six of its member states pledged to pilot the metalworking skill standards in publicly administered training programs. Representatives from the Council and involved states attend meetings of the Metalworking Industry Skill Standards Board and serve on an overall project steering committee.

The National Institute for Metalworking Skills, Inc., recognizes that career paths can develop from four major occupational groups in the metalworking industry. These are machining, tooling, metal forming, and industrial maintenance occupations. The Institute focuses on defining skills and recommends that each occupational cluster reflect increasing levels of competency or skills. Three skill levels are suggested for each major cluster.

2. Machining Skills--Level I-II-III
The general machining area includes three skill level standards that have been developed. Each has addressed similar skills with a graduated level of required precision or with newer and more complex technologies. Since the standards are entirely performance-based, individuals can advance at their own pace and be recognized for the skills they possess. The standards also provide employers with an objective assessment tool for worker performance and training needs.

Level I
Level I skills represent competencies that can reasonably be expected of an individual with one year of experience in a good shop or apprenticeship program; namely basic competency with common machine tools and accessories, basic shop math and inspection techniques, and basic ability to proceed with further, more advanced training.

Level II
At Level II, more complex machining skills are introduced, along with CNC principles, angular measurements, and additional auxiliary equipment.

Level III
Level III, in general, reaches into the journeyman competencies. It includes proficiency with a wide range of machine tools, auxiliary equipment, compound angles, task planning, and the ability to work with minimal supervision.

Curriculum Guidance
It should be emphasized that the standards are competency measures designed to drive training and they are not meant to be model training programs in and of themselves. In many cases elements of all three standards will appear in a metalworking training program depending on capabilities available in a training

facility or in certain companies where the concentration of work is in machine specific operations.

3. Education and Training

Most trainees can acquire the core Level I Machining Skills in six months to one year of education and training, depending on prior manufacturing experience, basic academic skills, mechanical aptitudes, and the availability of laboratory-based training. This training could be given in a high school or community college vocational/technical education program, apprenticeship program, formal company training program, or structured on-the-job training. Existing workers may be able to demonstrate their competence against the standards in shorter time periods and access necessary education and training through community colleges, private program training centers, retraining or upgrading.

4. Related Occupations in the United States

Related Standard Occupational Classification (SOC) and Dictionary of Occupational Titles (DOT) occupations that can include Level I Machining Skills are:

- Lathe and turning machine operators (SOC 7512)
- Milling and planing machine operators (SOC 7313, 7513)
- Grinding, abrading, buffing, and polishing machine operators (SOC 7322, 7324, 7522)
- Miscellaneous metalworking machine operators (SOC 7329)
- Grinding machine operators (DOT 603.482-034)
- Lathe operator, production (DOT 604.685-026)
- Milling machine operator, production (DOT 605.685-030)
- Drill press operator (DOT 606.682-014)
- Vertical band-saw/cut-off-saw operators (DOT 607.682-010)

5. Program (Curriculum) Standards in the United States

Major national, state, and local curriculum standards used in the United States that have been consulted in developing standards for Level I Machining Skills include:

- Ohio's Competency Analysis Profile-Machine Trades
- California Curriculum Standards-Manufacturing Technology, Machine Tools
- Similar State Vocational Education Competencies in Great Lakes States
- Chicago Machine Trades Advisory Group - Basic and Intermediate Levels.
- National Tooling and Machining Association, Competency Profile Certificate and Metalworking Training System, Level 1.
- Tooling and Manufacturing Association - Apprenticeship Programs, first year of related theory courses.
- International Association of Machinists and Aerospace Workers, Automotive and Metal Trades Apprenticeship Training Program, first year.
- ASTD Workplace Basics.
- SCANS Skills.

6. International Benchmarks

Major international occupational standards that have been used in benchmarking the Level I Machining Skills include:

- German Apprenticeship System, Metalcutting Mechanic, First Year Training Schedule.
- CEDEFOP (European Community), Setter/Operator of Production Machines, Metal Sector
- Japan National Association of High School Principals, certificate exams for mechanical drawing, industrial mathematics, and machinery-mechanical work.
- Japanese Ministry of Labor Trade Tests, Basic Training and Grade 1 Upgrading Training, machining, machine maintenance, machine part inspection.
- Australian Standard Framework, Metalcutting Occupations, Levels 1 and 2.
- Canadian JOBSCAN Profiles, Metalworking Machine Setters and Operators, Level 1.

7. Level 1 Machining Skills

An individual with Level I Machining Skills is a *skilled* machine operator or technician who has demonstrated competence in three major areas of responsibility:

1. basic bench operations
2. basic metal cutting operations
3. basic inspection and quality assurance functions.

This individual can perform these responsibilities in both single and multiple part production. No direct supervision or training responsibilities of other operators or other production workers is assumed at level I.

Level I Machining Responsibilities typically include the ability to:

(Note: These are not the standards)

Bench Operations:

- Select and use hand tools.
- Perform basic, routine layout.
- Read and comprehend information on orthographic prints and job process sheets for routine manufacturing operations.
- Deburr.
- Perform hand fitting and minor assembly.
- Perform bench cutting tasks such as sawing, reaming, and tapping.
- Perform basic, routine preventive maintenance.
- Perform basic housekeeping responsibilities.

Metal cutting operations:

- Identify basic metallic and non-metallic materials.
- Identify and use most accessories and tooling for machining operations.
- Choose an appropriate speed and feed for a given operation.
- Perform basic process planning, setup, and operation of common classes of machine tools such as turning, milling, drilling, or surface grinding machines.
- Select and use coolants appropriately.

• Make suggestions for improving basic machining operations within a structured improvement process.
• Be competent in all safety procedures for all machining operations and material handling and disposal within their responsibility.

Inspection and quality assurance responsibilities:
• Use basic precision measurement tools.
• Follow an inspection process plan.
• Perform basic quality assurance responsibilities for both single and multiple part production including statistical process control.

Other competency areas:
• Follow standardized work procedures in a limited range of standardized work contexts under direct supervision.
• Be competent in all basic aspects of seeking and maintaining employment in the metalworking industry.

Duty Framework for Level I Machining Skills:
Duties represent the most important responsibilities that workers are expected to perform. Each duty area may consist of a single or multiple duties. Each duty requires demonstrated competence for its execution. The duty competencies are defined as performance standards and include accuracy requirements that must be achieved within specified times. Each duty or standard also details the knowledge, academic skills, and other performance related characteristics that must be demonstrated to satisfy the standard. These duty standards are to be assessed by written and oral examinations, and performance examinations. These skill standards form the basis for awarding credentials of achievement. The duty framework for Level I Machining is described below in Table 11. The left-hand column lists the 7 duty areas and 25 duty titles of the Level I skills. The right-hand column identifies the knowledge, academic skills, and other characteristics that undergird the duties and must be mastered to meet the performance-based duty standards. Performance on each of the job execution duties can be assessed independently. Workers and trainees can demonstrate their ability to achieve or exceed the standards for job execution one duty at a time and receive credentials accordingly. Employers may prefer to describe jobs or positions by the mix of duty skills being sought. This framework is intended to encourage workforce development programs to modularize their approaches to curriculum development and program delivery.

Occupational Duties	Knowledge, Skills, Abilities, and Other Characteristics
1. Job Planning and Management 1.1 Job Process Planning	**1. Written and Oral Communications** 1.1 Reading 1.2 Writing

<table>
<tr><td></td><td>1.3 Speaking
1.4 Listening</td></tr>
<tr><td>2. Job Execution
2.1 Manual Operations Benchwork
2.2 Manual Operations Layout
2.3 Turning Operations-Between Centers Turning
2.4 Turning Operations-Chucking
2.5 Milling: Square Up a Block
2.6 Vertical Milling
2.7a Grinding Wheel Safety
2.7b Surface Grinding
2.8 Drill Press Operations
2.9 CNC Programming</td><td>2. Mathematics
2.1 Arithmetic
2.2 Applied Geometry
2.3 Applied Algebra
2.4 Applied Trigonometry
2.5 Applied Statistics</td></tr>
<tr><td>3. Quality Control and Inspection
3.1 Part Inspection
3.2 Process Control</td><td>3. Decision Making and Problem Solving
3.1 Applying Decision Rules
3.2 Basic Problem Solving</td></tr>
<tr><td>4. Process Adjustment and Control
4.1 Process Adjustment, Single Part Production
4.2 Participation in Process Improvement</td><td>4. Group Skills and Personal Qualities
4.1 Group Participation and Teamwork
4.2 Personal Qualities</td></tr>
<tr><td>5. General Maintenance
5.1 General Housekeeping and Maintenance
5.2 Preventive Maintenance
5.3 Tooling Maintenance</td><td>5. Engineering Drawings and Sketches
5.1 Standard Orthographic prints
5.2 GDT Orthographic prints
5.3 GDT Datum, Symbology and Tolerances</td></tr>
<tr><td>6. Industrial Safety and Environmental Protection
6.1 Machine Operations and Material Handling
6.2 Hazardous Materials Handling and Disposal</td><td>6. Measurement
6.1 Basic Measuring Instruments
6.2 Precision Measuring Instruments
6.3 Surface Plate Instruments
6.4 Metric Conversion</td></tr>
<tr><td>7. Career Management and Employment Relations
7.1 Career Planning
7.2 Job Applications and Interviewing
7.3 Teamwork and Interpersonal Relations</td><td>7. Metalworking Theory
7.1 Cutting Theory
7.2 Tooling
7.3 Material Properties
7.4 Machine Tools
7.5 Cutting Fluids and Coolants</td></tr>
</table>

7.4 Organizational Structures and Work Relations 7.5 Employment Relations	

Table 11: Framework for Level 1 Machining Skills

8. Level II Machining Skills
Occupational Description
Level II machining skills are used by skilled tradespersons who have achieved proficiency in the core competencies of Machining Skills—Level I and have advanced to higher levels of technical competency or have developed new competencies. The general areas of competency remain:
•bench skills
•metal cutting skills
•inspection and quality assurance skills
Level II machining skills apply to both single-part and multiple-part production. A person who has achieved Level II machining skills competency has no direct supervision responsibilities for other operators or production workers. However, people who have achieved Level II competence will occasionally provide training for beginning machining technicians.
Bench skills:
•Lay out hole locations on bolt circles, angular surfaces, profiles of a line, and points of tangency.
•Read and comprehend orthographic part prints using geometric dimensioning and tolerancing symbology.
•Read and comprehend part prints that have multiple auxiliary views.
Metal cutting skills:
•Use indexing devices to locate part features.
•Produce angled or tapered surfaces.
•Produce work to close tolerances (+/-.002 for milling and chucking, +/-.001 for boring and turning).
•Set up and operate a boring mill.
•Set up and operate a cylindrical grinder.
•Set up and operate CNC machine tools.
•Improve setups on common classes of machine tools.
•Achieve competence in all safety procedures for the tasks within the scope of Machining Skills—Level II.
•Select and use cutting fluids.
Inspection and quality assurance skills:
•Develop inspection procedures for in-process inspection.
•Inspect simple angles to required precision.
•Develop inspection process plans.
•Use optical comparator for inspection tasks.
•Use gage blocks for shop calibration of precision tools.
Other skills and competencies
•Write CNC programs.
•Qualify tools for CNC use.

•Participate effectively as a member of a team.
•Maintain employment in the metalworking industry.
•Articulate a personal career development plan within the metalworking industry.
•Produce process plans that identify operations, sequence, tools, fixtures, speeds, and feeds for parts requiring several of the basic machining operations such as milling, drilling, turning, or grinding.
•Record work activities.
•Write required reports using narrative style with paragraph structure composed of complete sentences.
•Succeed in interactive verbal and written communication.

Framework for Machining Skills--II
Table 12 represents the two principal sets of expectations that comprise Level II machining skills. The left-hand column is a list of duties that are expected to constitute Level II jobs. The right-hand column is a list of the abilities, skills, knowledge, or other characteristics needed to perform the duties

Occupational Duties	Knowledge, Skills, Abilities, and Other Characteristics
1. Job Planning and Management 1.1 Job Process Planning	**1. Written and Oral Communications** 1.1 Writing 1.2 Reading 1.3 Speaking 1.4 Listening
2. Job Execution 2.1 Layout Bolt Circles, Angles, Points of Tangency and Profiles of a Line. 2.2 Contour Bandsawing 2.3 Turning : Between Centers Taper Turning 2.4 Turning: Chucking O.D.and I.D.Tapers using a Taper Attachment 2.5 Vertical Mill: Precision Location of Holes 2.6 Milling: Keyseat 2.7 Milling: Deep Slots with a Staggertooth Cutter 2.8 Milling: Rotary Tables 2.9 Milling: Dividing Head Operations 2.10 Basic Horizontal Boring Mill Operations 2.11 Drilling: Radial Drill	**2. Mathematics** 2.1 Geometry of Simple Angles & Profiles of a Line 2.2 Coordinate Axes, Cartesian and Polar 2.3 Trigonometry for CNC Tool paths 2.4 Statistics for Capability Studies

2.12 Machine Power Tapping: Taper Reaming & Pipe Tapping 2.13 Surface Grinding: Finish Flats to +/-.0005 2.14 Surface Grinding: Finish Flats at Simple Angles and Grind Contour Radii. 2.15 Grinding Wheel Preparation and Balancing 2.16 Cylindrical Grinding 2.17 EDM: Produce an Electrode and Operate a Plunge EDM 2.18 EDM: 2 Axis Wire EDM 2.19 CNC: Simple RS274-D Programs 2.20 CNC: Operate a CNC Milling Machine 2.21 CNC: Operate a CNC Lathe	
3. Quality Control and Inspection 3.1 Inspection: Optical Comparator 3.2 Inspection: Manual Coordinate Measuring Machine	**3. Engineering Drawings and Sketches** 3.1 Isometric and Orthographic Sketching 3.2 Interpreting: GDT 3.3 Interpreting: Auxiliary Views
4. Process Adjustment and Control 4.1 Participate in Capability Studies	**4. Measurement** 4.1 Basic Measuring Instruments 4.2 Precision Measuring Instruments 4.3 Surface Plate Instruments
5. General Maintenance 5.1 General Housekeeping and Maintenance 5.2 Preventive Machine Maintenance 5.3 Tooling Maintenance	**5. Metalworking Theory** 5.1 EDM: Electrode Selection and Design 5.2 CNC Machine Tools 5.3 CNC Tooling 5.4 Correct Coolants and/or Cutting Fluids for Various Applications
6. Industrial Safety and Environmental Protection 6.1 Machine Operations and Material Handling 6.2 Hazardous Materials Handling and Storage	**6.Applied Materials** 6.1 Metal Properties Applied to Cutting Problems 6.2 Non-metal Properties Applied to Cutting Problems
7. Career Management and Employment Relations	**7. Computers** 7.1 Typing

7.1 Career Planning 7.2 Job Applications and Interviewing 7.3 Teamwork and Interpersonal Relations 7.4 Organizational Structures and Work Relations 7.5 Employment Relations	7.2 Use of Basic Services of an Operating System

Table 12: Framework for Level 2 Machining Skills

9. Level III Machining Skills
Occupational Description
Machining Skills—Level III are used by skilled tradespersons who have achieved proficiency in the core competencies of Machining Skills I and II and have advanced to higher levels of technical competency or have developed new competencies. The general areas of competency remain:
•Bench skills
•Metal cutting skills
•Inspection and quality assurance skills
Machining Skills—Level III applies to both single part and multiple part production. A person who has achieved Machining Skills III competency may have modest supervision responsibilities for other operators or production workers. Additionally, people who have achieved Skills III competence will be called upon to provide training for machining technicians.
Bench skills
•Lay out of hole locations on bolt circles, angular surfaces, profiles of a line and points of tangency.
•Read and comprehend complex orthographic blueprints using geometric dimensioning and tolerancing symbology.
•Read and comprehend blueprints that have multiple auxiliary views.
•Hand lap small surfaces.
Metal cutting skills:
•Use indexing devices to locate part features.
•Produce compound angled and irregular surfaces.
•Produce work to close tolerances.
•Set up and operate a boring mill.
•Set up and operate a cylindrical grinder.
•Set up and operate CNC machine tools.
•Improve setups on common classes of machine tools.
•Gain competence in all safety procedures for all tasks within the scope of Machining Skills—Level III.
•Select and use cutting fluids.
Inspection and quality assurance skills:
•Develop and document inspection procedures for in-process inspection.
•Inspect compound angles to required precision.
•Develop inspection process plans.

•Use visual comparator for inspection tasks.
•Use gage blocks for shop calibration of precision tools.

Other skills and competencies:

•Write CNC programs requiring multiple tools, planes, canned cycles, and offsets.
•Qualify tools for CNC use.
•Participate effectively as a member of a team.
•Maintain employment in the metalworking industry.
•Articulate a personal career development plan within the metalworking industry.
•Produce process plans which identify operations, sequence, tools, fixtures, speeds and feeds for parts requiring several of the basic machining operations such as milling, drilling, turning, or grinding.
•Record work activities.
•Write required work reports.
•Succeed in interactive verbal and written communication.
•Train others as assigned.
•Perform supervisory duties.

Duty and Skills Standards Table

The left-hand column in Table 13 is a list of activities performed on the job. The right-hand column is a list of the abilities, skills, knowledge, or other characteristics that are needed to perform the duties.

Occupational Duties	Knowledge, Skills, Abilities, and Other Characteristics
1. Job Planning and Management 1.1 Job Process Planning	**1. Written and Oral Communications** 1.1 Reading 1.2 Writing 1.3 Speaking 1.4 Listening
2. Job Execution 2.1 Bench Operations: Hand Lapping 2.2 Angle Contour Bandsawing 2.3 Turning Operations: Manual Contour Turning 2.4 Turning Operations: Steady Rest Turning & Boring 2.5 Turning Operations: Follower Rest Turning 2.6 Turning Operations: Difficult Materials 2.7 Milling: Mill Compound Angles 2.8 Milling: Manual Contour Milling 2.9 Horizontal Boring Mill: Line Boring	**2. Mathematics** 2.1 Geometry of Compound Angles, Profiles of a Line and Profile of a Surface

2.10a Grinding: Select, Inspect, Set up, & Balance Wheels 2.10b Grinding: Tapered Cylindrical Grinding 2.11 Grinding: Grind I.D. and O.D. Surfaces 2.12 Grinding: Grind Tapers on an Universal Grinder 2.13 Grinding: Contour Grinding 2.14 EDM: Operate a 4 Axis Wire EDM 2.15 CNC: Advanced Manual RS-274-D Programming 2.16 CNC: Use Manufacturing Modeling Software to Create RS-274-D Programs 2.17 CNC: Milling Centers 2.18 CNC: Turning Centers 2.19 CNC: Turning Centers with Secondary Milling	
3. Quality Control and Inspection 3.1 Part Inspection 3.2 Process Control	**3. Computer Aided Manufacturing Technology** 3.1 Computer Aided Manufacturing Software
4. Process Adjustment and Control 4.1 Process Adjustment, Single Part Production 4.2 Participation in Process Improvement	**4. Decision Making and Problem Solving** 4.1 Applying Decision Rules 4.2 Basic Problem Solving
5. General Maintenance 5.1 General Housekeeping and Maintenance 5.2 Preventive Maintenance 5.3 Tooling Maintenance	**5. Group Skills and Personal Qualities** 5.1 Group Participation and Teamwork 5.2 Personal Qualities
6. Industrial Safety and Environmental Protection 6.1 Machine Operations and Material Handling 6.2 Hazardous Materials Handling and Disposal	**6. Engineering Drawings and Sketches** 6.1 Standard Orthographic Blueprints 6.2 GDT Orthographic Blueprints
7. Career Management and Employment Relations	**7. Measurement** 7.1 Basic Measuring Instruments

7.1 Career Planning 7.2 Job Applications and Interviewing 7.3 Teamwork and Interpersonal Relations 7.4 Organizational Structures and Work Relations 7.5 Employment Relations	7.2 Precision Measuring Instruments 7.3 Surface Plate Instruments

Table 13: Framework for Level 3 Machining Skills

10. Detailed Duty Descriptions

Each of these duties has a detailed description of the performance standards, evaluation criteria, and required equipment and materials. For example, Duty 1.1 of Level II would have the following description:

Duty Area: 1. Job Planning and Management

Duty Title: 1.1 Job Process Planning

Duty:

Write a detailed process plan that includes a quality plan for a part requiring milling, drilling, turning, or grinding. Produce an operation sheet detailing the process plan; identify all critical dimensions and required speeds and feeds. Provide sketches as needed.

Performance Standard:

Given a print detailing a part requiring milling, drilling, turning, and grinding, verbal instructions, and appropriate references, formulate a set of strategies to manufacture the part, and write a detailed process plan including a quality plan for that part. Provide sketches as needed.

Make a presentation explaining each of the process plan steps to be taken; identify all major components and functions of the machine tools, and all major hand tools, measuring tools, tools and fixtures, and work materials, provide the rationale for the speeds and feeds selected.

Other Evaluation Criteria:

1. Legibility

2. Clarity of the writing

3. Appropriate speeds and feeds

Accuracy Level: N/A

Assessment Equipment and Material:

Workstation: Standard workbench

Material: Part print with an appropriate part, an inventory of available tools, and necessary writing materials

Tooling: N/A

Measuring Instruments: N/A

Reference: Machinery's Handbook

KSAO:

Table 14 represents the kinds of knowledge, skills, abilities, or other characteristics that will be assessed in the performance of the Job Process Planning Duty.

	1. Written and Oral Communications		**4. Measurement**
X	1.1 Reading	X	4.1 Manual Coordinate Measuring Machine
X	1.2 Writing		**5. Metalworking Theory**
X	1.3 Speaking	X	5.1 EDM: Electrode Selection and Design
X	1.4 Listening	X	5.2 CNC Machine Tools
	2. Mathematics	X	5.3 CNC Tooling
X	2.1 Geometry of Simple Angles & Line Profiles	X	5.4 Coolants and Cutting Fluids for Various Applications
X	2.2 Coordinate Axes, Cartesian & Polar		**6. Applied Materials**
X	2.3 Trigonometry for CNC Toolpaths		6.1 Apply the Properties of Various Metals to Cutting Problems
X	2.4 Statistics for Capability Studies		6.2 Apply the Properties of Non-metals to Cutting Problems
	3. Engineering Drawings and Sketches		**7. Computers**
X	3.1 Isometric and Orthographic Sketching		7.1 Typing
X	3.2 Interpret GDT Drawings		7.2 Services of an Operating System
X	3.3 Interpret Engineering Drawing: Auxiliary Views		

Table 14: Knowledge, Skills, Abilities, and Other Characteristics

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