ALTERNATIVE ASSESSMENT OF COMPUTER NUMERICAL
CONTROL (CNC) MACHINE TOOL STUDENTS

by

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ABSTRACT

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Vocational Education curriculum is constantly in a state of flux due to the ever changing technological workplace. Traditional assessment methods are challenged to accurately assess the adult learners returning to post-secondary education.

Industry demands high expectations with regards to occupational skills from these adult learners. The educational experience can be enhanced by using assessment methods as techniques for evaluation and as guides for instructors and administrators in curriculum design and technique methods (Paul, Lewis & Simpson 1994). Current traditional assessment methods may be inadequate for evaluating critical thinking skills.

This study outlined and described some of the alternative assessment methods that are being used in post-secondary vocational education at the time of this study. Additionally, a list of recommendations for selecting and applying alternative assessment methods for CNC machine tool students was developed. These recommendations were derived from what the research and survey indicated to be appropriate for CNC machine tool students at MATC and other similar institutions.

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endeavor.

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CHAPTER 1

Introduction

Traditionally, school and college curricula focuses on concepts, facts, and procedures related to various subjects. For example, they customarily rely on memorization of dates and events for history, formulas for mathematics, lists of properties for science, and structure format for writing. However, to operate effectively in other settings, such as in vocational education, students also need three other types of content:

1. Problem solving strategies developed through work experience, commonly called "Tricks of the Trade".

2. Cognitive management strategies--goal setting, strategic planning, monitoring, evaluation, and revision.

3. Learning strategies--knowing how to learn, including exploring new fields, getting more knowledge in a familiar subject, and reconfiguring knowledge already possessed. (Berryman, p. 4)

These are critical thinking skills that are increasingly believed to be a vital part of professional practice in a wide variety of occupations. Consequently, The U.S. Department of Education in 1993 (Education Goals 2000), mandated the demonstration of a significant improvement in critical thinking in all of our nation's college graduates. As a result, at least eight states have already mandated critical thinking skills assessment for graduating post-secondary students (Facione, 1995). Alternative assessment, which utilizes a variety of measurement methods, is ideal for evaluating critical thinking skills. Facione

(1995) stated, "The assessment of critical thinking lends itself to the full array of measurement methods." (p. 5). These assessment devices each have a different potential for assessing critical thinking. Also, critical thinking requires alternative assessment, not merely the traditional evidence of content knowledge.

Vocational education curriculum is designed to make the student employable in at least one occupation. These occupational fields may include agriculture, business, office, health, home economics, trade, industrial, and technical areas (Dejnozka & Kapel, 1991). Students enrolled in these occupational programs are usually adults that may range in ages from 18 to 65. These occupations are continually changing due to the rapid pace of technology. Workers will often find themselves subject to changes in their workplace resulting from automation or technological innovations. Therefore, working adults must continually update, maintain, or even learn new technical knowledge or skills. This can be accomplished through vocational education curricula offerings.

The adult learner can be defined as an individual who is no longer attending school or college and voluntarily selects instruction or education in a program that meets his or her educational, emotional, or psychological needs (Dejnozka & Kapel, 1991). Also, adult learners are frequently unsure of what or how to study. Consequently, they spend more time anxiously awaiting the traditional test than they do learning and summarizing the course content. Therefore, nontraditional assessment methods need to be examined to determine their effectiveness in vocational education settings. In contrast with

traditional assessment methods, alternative assessment methods facilitate relearning, synthesizing, and application.

Alternative assessment can be defined as a process for gathering information to meet a variety of evaluations or appraisal needs. The assessment process is designed around multiple indicators and sources of evidence which distinguish it from traditional testing. Adult educators should be highly interested in assessing what materials and information were learned, assimilated, and applied (Reif, 1995).

Alternative assessment methods may include portfolios, rubrics, peer evaluations, take-home tests, self-evaluations, learning contracts, oral examinations, journals, classroom participation, reports, simulations, projects, mastery, and collaborative groups.

Paul, Lewis & Supon (1994) stated that, "The educational experience can be enhanced by using assessment methods as techniques for evaluation and as guides for instructors and administrators in curriculum design and teaching methods." (p. 1). Traditional assessment is used by teachers primarily to assign grades at the end of a unit of instruction and to distinguish the students who are successful from those that are not (Wilcox, 1997). Conventional evaluation tools are instructor-administered as either a midterm or final exam. These tests are typically designed in the traditional format that may include multiple choice questions, true or false questions, an essay, matching answers, and short answer questions (Reif, 1995).

Alternative assessment of adult learners in vocational education can be useful to both the student and the instructor. Reif (1995) stated, "Alternative or authentic assessment of adult learners can provide more opportunities for higher levels of thinking, development of individual learning styles, cooperative efforts and real-world applications, although this process will shift the role of an educator to that of a facilitator" (p.12). By utilizing alternative assessment methods, instructors can assess and evaluate how students are developing in a variety of ways (Manning & Manning, 1997). The main concerns that alternative assessment can answer for the instructor include:

1. What do students seem to understand.

2. What are students struggling with.

3. What is the next instruction (Wilcox & Zielinski, p. 228).

For the students, alternative assessment gives feedback on their progress towards the development of knowledge, comprehension, skills, and attitudes (Trigwell, 1992). The traditional practice of using one score or assessment method to evaluate students is not reliable for making high-stakes educational decisions, especially in post-secondary vocational education (George, 1997).

Milwaukee Area Technical College (MATC) is one of the oldest and largest post-secondary technical colleges in the nation. MATC has earned a reputation as one of the finest two-year colleges in America. Also, MATC is a national leader in technical education which has the most advanced Computer Integrated Manufacturing (CIM) Development Center of any technical college in the United States (MATC Catalog, 1997-98). MATC prepares students for a wide

variety of occupations and helps individuals advance in their careers through continuing education. MATC provides skilled trades instruction for apprentices under joint contracts with employees, employers, and the state. MATC conducts over 600 courses for business and industry that are developed and taught by MATC instructors. Today, MATC has an enrollment of over 70,000 students annually.

The machine tool programs at MATC include: Computer Numerical Control Machine Operator/Programmer; Computerized Machining Technician; Machine Tool Operations; Automatic Screw Machine Setup and Operation; and Tool and Die Making (MATC Catalog, 1997-98).

The students in these programs are exposed to various levels of hands-on operation of manual and Computer Numerical Control (CNC) machines. This student population is in the post-secondary vocational education category. To date, very little has been done to introduce alternative assessment methods into the curricula of these post-secondary machine tool programs. Consequently, there is potential for overall improvement of these machine tool programs by utilizing alternative assessment methods.

Statement of the Problem

The adult learner in post-secondary vocational education is customarily evaluated by traditional methods of assessment. Businesses and industries expect these students to learn or update the technical skills that are required to perform their jobs. Additionally, businesses and industries are also demanding

that the students learn to be critical thinkers. The traditional assessment methods may be inadequate for evaluating critical thinking skills.

Purpose of the Study

This study identified alternative methods of assessing adult learners in technical and vocational machine tool programs at MATC. The focus of this study concentrated on determining ways to improve student evaluation and feedback for the machine tool instructor.

Research Questions

This study answered the following three research questions:

1. Which alternative assessment methods are used in post-secondary vocational education?

2. Which alternative assessment methods are best designed for post-secondary adult learners in vocational education?

3. Which alternative assessment method is appropriate under which conditions?

Significance of the Study

This study resulted with a list of recommendations for selecting and applying alternative assessment methods that can be used to evaluate both technical and critical thinking skills of machine tool students. These results can serve as a basis for assessment training of new machine tool instructors and updating the assessment skills of other machine tool instructors. Also, the data from this study can serve as a guide for other administrators or instructors at MATC that may wish to consider implementing alternative assessment methods

into their programs. Additionally, other institutions similar to MATC can use information from this study as a pattern for implementing alternative assessment methods into their programs.

<u>Limitations</u>

1. One limitation of this study was that only post-secondary vocational education students were included in the research.

2. Adult learners who are persons attending a post-secondary vocational school or college, and are 18 years old or older, were used for this study.

3. This study was limited to research that was available from 1994 to the present.

4. All examples and recommendations are directed to the machine tool programs at MATC and may not entirely apply to other vocational education programs.

<u>Definition of Terms</u>

The following terms are defined for clarity and understanding of the material in this study.

<u>Alternative Assessment</u>: For this study, nontraditional methods of student evaluation.

<u>Assess</u>: To determine the value, significance, or extent of appraise.

<u>Assessment</u>: For this study, students' evaluation of performance.

<u>Adult learner</u>: For this study, a person attending a post-secondary vocational school or college who is 18 years of age or older.

Critical Thinking: For this study, the ability to use higher levels of cognition to solve problems.

Evaluate: To ascertain or fix the value or worth of.

Feedback: The return of a portion of the output of a process or system to the input, especially when used to maintain performance or to control a system or process.

Machine Tool: For this study, a technical program which involves the set up and operation of lathes, mills, and computer numerical control (CNC) machines in a vocational college.

Standardized Test: For this study, the process of evaluating students using traditional tests such as: true or false, multiple choice, essay, fill in the blank, or matching.

Vocational Education: For this study, instruction and/or education where the curriculum is designed to make the student employable in at least one occupation.

CHAPTER 2

Review of Literature

This study identified alternative methods of assessing adult learners in technical and vocational machine tool programs at MATC. The focus of this study was concentrated on determining ways to improve student evaluation and feedback for the machine tool instructor.

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1. Which alternative assessment methods are used in post-secondary vocational education?

2. Which alternative assessment methods are best designed for post-secondary adult learners in vocational education?

3. Which alternative assessment method is appropriate under which condition?

The review of literature revealed that, assessment of adult learners should serve as the essential link between the curriculum, the delivery of instruction, and the learning process. Paul, Lewis & Supon (1994) stated that, "The educational experience can be enhanced by using assessment methods as techniques for evaluation and as guides for instructors and administrators in curriculum design and teaching methods." (pg. 1).

The literature also revealed that assessment is used by teachers primarily to assign grades at the end of a unit of instruction and to distinguish the students who are successful from those that are not (Wilcox, 1997). Conventional

evaluation tools are instructor-administered as either midterm or final exams. They are typically in a traditional format that may include multiple choice, true or false, essay, matching, and short answer (Reif, 1995).

Assessment is defined as a process for gathering information to meet a variety of evaluation or appraisal needs. The assessment process is designed around multiple indicators and sources of evidence, this is what distinguishes it from testing. Adult educators should be interested in assessing what materials and information were learned, assimilated, and applied (Reif, 1995).

Vocational education curriculum that is designed to make the student employable in at least one occupation is more apt than academic education to use some of the methods of cognitive and cooperative learning (Berryman, 1997).

Alternative assessment of adult learners in vocational education can provide more opportunities for higher levels of thinking, development of individual learning styles, cooperative efforts and real-world applications. By applying alternative assessment methods, instructors can assess and evaluate how students are developing in a variety of ways (Manning & Manning, 1997).

Student performance was observed in the classroom to develop these findings and recommendations. Reif said:

Several issues should be considered when implementing new forms of student evaluation: Give clear directions; Be flexible to student creativity and interpretation; Provide written guidelines for grading the assessment--hand out the rubric when giving the original directions and

attach the completed form when handing back the assessment; Check with other adult educators in your site, do not use the same type of assessment that they are using in their courses (i.e. a learner could be required to keep three journals during the term); Provide time or resources for completing the research necessary for the paper, project, or presentation (this may include offering a library orientation session for some adults); Do not think you must be a writing expert to evaluate writing; Do not assign more than you plan to read (grade the most important components that demonstrate that the student has done an effective assessment, do not grade just the easiest sections); Vary your assessments, students are a collection of individuals with a variety of learning styles, interests, and skills. (1995, p. 14)

There are various alternative assessment methods that lend themselves to a variety of applications in post-secondary vocational education. It is clear that traditional methods of assessment that are customarily used are not adequate to meet the demands of the adult learners attending post-secondary vocational schools today.

Businesses and industries expect their employees to learn or update new technical skills that are required to perform their jobs. Additionally, businesses and industries are also demanding that their employees learn to solve problems and be critical thinkers.

The Adult Learner

In a society marked by rapid technological change, education must continue throughout life for professional updating, inevitable career changes and the maintenance of competence to deal with a changing society (Husen & Postlethwaite, 1994). The forms of post-secondary and adult education change over time, but some of the principles that distinguish the mature and older learner from the traditional young student clearly emerge from the psychological literature.

First, it is most likely that older learners have had quantitatively less education than contemporary young adults have had. Qualitative changes in methods of instruction may also place the re-entrant into formal education at some disadvantages. Second, cumulative physiological changes to the central nervous system will result in slower response speed requiring redundancy in the exposure to educational materials and in the acquisition of new skills. Third, older learners often do not spontaneously use encoding strategies to process new information. Fourth, older learners often use accumulated knowledge structures to compensate for age-related deficits, particularly circumstances with which the older learners may have greater familiarity (Husen & Postlethwaite, 1994).

Educators can greatly enhance formal and informal learning in older individuals by understanding these principles and applying them to their practice. For example, although older learners hesitate to employ coding strategies spontaneously, they are quite capable of using such strategies. Instructors can provide mnemonics to assist recall of technical terms. Rehearsal may be used

when the goal is to retain information in short-term memory, and organizational strategies may be useful for encoding into long-term memory. It is particularly important that reading materials be well organized for older learners. Research on text recall shows that older learners remember the gist of a well organized text as well as younger people, but that age differences increase when key points in the text are hard to identify (Husen & Postlethwaite, 1994). The increased use of examples in instructional material has also been found to be helpful. In assessing what has been learned, older persons are likely to be less disadvantaged when the text is based on recognition rather than recall.

Schaie & Willis (1987) developed and administered a series of cognitive training studies of older persons. They found that specific ability training (such as ability domains of inductive reasoning or spatial orientation) may enhance basic skills in those who have not declined but who are at a disadvantage when compared to younger learners. The disadvantage may stem from the limited educational experience they received in youth (cohort differences), as well as in those who have declined from previous levels due to disuse or lack of relevant intellectual stimulation.

Cognitive training efforts are now being expanded to specific domains of everyday tasks or what is sometimes termed "practical intelligence" (Husen & Postlethwaite, 1994). The implication being that students in their adult stages will achieve at higher levels when nontraditional learning and assessment techniques are applied.

Trigwell (1992), of the University of Technology, Sydney, conducted a study that identified and examined the alternative assessment methods that were being used in education. The following list explains these various assessment methods in brief detail.

Mastery Assessment

This method employs mastery tests at frequent intervals to test student performance in a formative way. Also, this approach is dependent upon the model of mastery learning and teaching which was introduced into the professional literature in the late 1960s (Trigwell, 1992).

In this model of learning, each student is expected to answer all items correctly and to practice a skill or revise the content presented until such a standard is achieved. Since it is recognized that perfection is difficult to attain and that some errors inevitably occur, a mastery level of 80% to 90% is commonly set. Where a student fails to provide the correct answer, either the error is due to carelessness, in which case the 90% criterion allows for this situation, or there is a deficiency in the mastery of the skill or field of knowledge. In such circumstances the occurrence of the error provides diagnostic information.

Many classroom teachers administer at regular intervals short mastery tests to their students on a limited body of knowledge or on the development of a specific skill, and they expect a high level of performance from all students. The results of mastery testing are expressed in two categories - master or non-

master, and the information on the assessment of mastery is primarily of interest

to the student and teacher.

Multiple - Choice Questions

Multiple-choice questions (MCQ) are a subset of what are referred to as

"objective questions." Objective questions are questions that usually have only

one correct answer (Trigwell, 1992). The term "objective" here means there is

complete objectivity in marking the test. The construction, specification and

writing of the individual questions are influenced by the judgment of examiners

as much as in any other test.

This type of test is largely used to test factual material and the

understanding of concepts. Because of the objectivity and ease of marking, it is

frequently used for testing large groups. It is claimed that skilled writers can

develop items that can test higher levels of intellectual skills. However, if the

perception of students is that these types of questions usually test recall of facts,

then they will prepare for them accordingly.

Generally, MCQ tests can sample a broad range of a course; they are

rapidly marked; students are not able to "bluff" or "pool" answers; scoring is

objective and reliable (i.e. no halo effect); distribution of scores is determined by

the test scores--not the examiner; only the objectives tested for are marked; and

important items may be stored in an item bank and reused. However, MCQ tests

are time consuming to develop; there is no credit for partial information; effective

MCQ tests are difficult to develop; students "select" the information; and MCQ

tests may encourage reproductive learning.

Essays

Standard form of essays require that students discuss a quotation; or write an essay on a particular subject; or describe, give an account of, compare, assess, analyze, or evaluate a subject (Trigwell, 1992).

While these types of questions give students the freedom to choose what they will concentrate on and to structure their work themselves, they may also leave the weaker students in some dilemma as to what is required. In addition to these types of questions, there is a range of alternatives that can be employed to fulfill certain roles or to suit different objectives.

Grading of essays is a notoriously unreliable activity. If we read an essay at two different times, the chances are good that we will give the essay a different grade each time. If two or more of us read the same essay, our grades will likely differ, often dramatically, so we all like to think we are exceptions, but study after study of well meaning and conscientious teachers shows that essay grading is unreliable.

Eliminating the problem is unlikely, but there are steps we can take to improve grading reliability. For example, using a scoring guide helps control the shifting of standards that inevitably take place as we read a collection of essays and papers. The two most common forms of scoring guides used in universities are analytic and holistic (Trigwell, 1992). Those who use analytical scoring guides identify important components of the essay and assign marks to each component as they read the essay, they award marks up to the limit specified by the scoring guide and then total the points to determine the essay's grade.

Holistic grading methods assume that an essay is other than a sum of particular parts so we read the essay as a whole. Whereas the analytic scoring guide designates marks for particular aspects of the essay, the holistic scoring guide describes the characteristics of excellent, good and not so good essays.

Essays are generally categorized into three types. The three types of essays, which are briefly outlined below, include Role-Play Essays, Structured Essays, and Interpretation of Evidence Essays (Trigwell, 1992).

In Role-Play Essays, students respond to an essay question from the perspective of a position given in the essay question. They help students see relevance of the task and take an interest in it. Their writing often becomes more fluent and natural. Even small elements of simulation or role-play can dramatically change a student's approach to questions.

There is, however, a danger of encouraging too flippant an approach, but this can be kept in check by careful phrasing of the questions. For example, ask the student to write to someone in an official position, such as their supervisor or the managing director.

Structured Essays require students to respond to an essay question which contains specific areas or parts of the question that requires an answer.   For example: undertake a stylistic analysis of the following passage, select, arrange and comment on features of syntax, lexis, semantics and (where relevant) phonology. Relate the artistic effects of the passage to the writer's choice of language (Trigwell, 1992).

By specifying the content required in an essay, it is possible, when marking, to be clearer whether students know about and understand the specific items, which you believe, matter. It is difficult to know whether students would comprehend which item matters without prompting. However, this type of essay is useful when you are testing specific knowledge and techniques.

Interpretation of Evidence Essays requires that the students be supplied with data or evidence. Using that evidence (which in many subjects with mini projects or laboratory exercises students may have collected themselves), the students are asked to write an essay in which they address a question on that evidence. The questions and the data can relate directly to an exercise previously conducted by the students in which they collected, analyzed and interpreted data. Interpretation questions require the students to undertake the analysis "live" and this can avoid regurgitation.

Short Answer Questions

A large proportion of assessment items makes use of short answer questions of some form or another (Trigwell, 1992). For example, they are used in assignments, quizzes, examinations, and laboratory tests. These questions vary in expected student response from one word or several lines to over a page. They may include forms such as complete the sentence, supply the missing line, problems and exercises in science-based subjects, short descriptive or qualitative answers, essay plans, diagrams with explanation, and so forth. The diversity of form means that no generic description is possible, but they are included in this section for completeness.

Short answer questions can be addressed toward the testing of a specific objective and the answers are easier to mark. This is also true of multiple choice questions, but short answer questions have the advantage of avoiding, cueing and requiring students to supply an answer, rather than selecting or guessing from options supplied. Also, the form of the question is familiar to students and they feel less anxious in examination situations (Trigwell, 1992).

However, individual questions for individual objectives fragment the subject and reduce the likelihood that students in their studies will look for relations between objectives or sections of the subject. Also, complex issues cannot always be satisfactorily addressed in short answers.

When preparing short answer questions, be precise and if a numerical answer is required, indicate the units and degrees of precision required. A structural-marking sheet should be prepared which also allocates marks or part-marks for acceptable answer(s). Also, mark anonymously and be prepared to accept other equally acceptable answers, some of which you may not have predicted (Trigwell, 1992).

Take Home Examinations

An examination method more in keeping with the type of "tests" students will encounter in their careers is the take home exam (Trigwell, 1992). Students are given the examination paper and 2 to 7 days to submit responses. It assesses their ability to research, redraft, and use resources, and places less emphasis on speed and memory than conventional exams.

Take Home Exams eliminate memorizing, question spotting, and reduce pre-examination anxiety. This encourages students to keep good notes and respond with higher quality answers. However, student competition for library books and the likelihood of students getting expert help is increased.

Revealed Examination Questions

An excellent way to inform students about what is important in a subject is to show them the examination at the beginning of the semester (Trigwell, 1992). The examination should contain a broad question on each major topic of the subject (approximately 8 questions). The students should be told that the final examination will only contain (for example) three of the exam questions and they will be required to completely answer all three.

In this type of assessment, students are clear about the course requirements and the exam answers are of a higher quality. Also, students are obligated to study all areas of the course (this does not happen with conventional examinations). However, with this assessment type, there is an increased likelihood that students may seek assistance from other external sources.

Peer Assessments

Peer assessment, in which students comment on their colleagues' work, has a vital role to play in formative assessment, but it can also be used as a component in a summative assessment package (Trigwell, 1992). One of the desirable outcomes of education should be an increased ability in the learner to make independent judgments of their own and others' work.

Peer self-assessment exercises are means by which these general skills can be developed and practiced. A peer rating format can encourage a greater sense of involvement and responsibility, establish a clearer framework and promote excellence, direct attention to skills and learning and provide increase feedback. In items of summative assessment, studies have found students' ratings of their colleagues to be both reliable and valid. These studies also determined that there was no difference between lecturer and student ratings of assignments in terms of average ratings, variations in ratings, agreement in ratings or relationship between ratings (Trigwell, 1992). Other studies suggest there is variation according to factors such as age of the student. Reports of the types of assessments where peer assessment is used for summative purposes include essay writing, clinical skills, speeches and small group activities.

Peer Assessment helps students to become more autonomous, responsible, and involved. It encourages students to critically analyze work done by others, and helps clarify assessment criteria. Peer Assessment also more closely parallels possible career situations where the group makes judgment and gives students a wider range of feedback.

However, with peer assessment, problems may develop if students lack the ability to evaluate each other or do not take it seriously, allowing friendship, other activities, and so forth, to influence their marking. Also, without the lecturer's intervention, students may misinform each other, and students may not like peer marking because of the possibility of being discriminated against, being misunderstood, and so forth.

Oral Exams

The oral examination is an excellent discriminator, it makes it readily apparent if students do not have a sound basic understanding of their topics (Trigwell, 1992). The oral examination is an opportunity for students to use their oral communication skills in a formal but flexible context. Although the examination takes a long time to administer, there is, of course, minimal "marking" time required. The size of the group involved has never exceeded thirty students; it would be very difficult with limited staff to use this method with large groups.

Surveys of student opinion have elicited favorable comments on the oral examination as a method of assessment. Most students say they found the experience much less threatening than anticipated, and felt that it gave them an opportunity to demonstrate what they had learned during the semester. However, Oral Exams require special skills of the examiners and some training for professional interviewers should be available.

Projects

Project work is an attempt to introduce genuine problems into education (Trigwell, 1992). In it, students have to use their initiative to identify problems they wish to solve or questions they wish to explore. They decide on the information, materials, equipment needed and how they can obtain them. They use this information to plan the work, attempt to solve the problem, or answer the question and present their results coherently.

The way to assess project work requires a variety of activities, which also constitutes the work. Therefore, each of the following activities need to be addressed separately:

* Identification and formulation of the problem.

* Information and resources needed.

* Planning the work.

* Solving the problem or answering the questions.

* Presentation, discussion and interpretation of the results.

* Critique of the work and recommendations for further work.

However, if only one assessment item (the project report or project product) is used, it is important that students receive meaningful feedback to assist the learning process and provide students with an approximate idea of their chances of passing the subject. If this is not done, students will concentrate their main efforts on the final product and not on the work preceding it. Most projects are assessed on more than the final report, or product, by including forms such as oral examinations, observations, assessment of methodology, and so forth (Trigwell, 1992).

The great advantages of project work in higher education also create many problems. Projects provide a means through which a topic can be covered in depth, but the assessment becomes a time consuming and subjective task. The project requires students to undertake independent study and inquiry, but this creates differences in equality of tasks, and in the development of common grading schemes. Projects encourage students to work together in-group, but

student contributions are not always equivalent, and awarding grades is a problem.

Group Work

Students involved in group work each conduct a proportion of the project work (Trigwell, 1992). An advantage of group work includes the enhanced learning resulting from combing the knowledge and experiences of several students. Also, group work is more closely allied to the type of work many students will experience in their careers, and the quantity of marking can be reduced. One of the major disadvantages felt by many students is the injustice of awarding one mark to a group in which the contribution from individual students has not been equivalent.

A submission from the School of Teacher Education suggested that in a group project or assignment that has an overall assessment weighting of over 20%, students should be given the option of an individual mark. One way of achieving this is to award the group one grade, but allow them to decide how that mark should be distributed among themselves. For example, if a group containing five members achieves a project grade of 60%. The group will be given 300 marks (60 x 5) and asked to allocate a mark for each person where no one can be given less than zero or more than 100 and the total is 300. Students will have to agree on the criteria being used to make this decision, and may learn some negotiating skills in the process. They can be asked to prepare for this negotiation by keeping minutes of meetings, diaries of events, or drafts of contributions.

Rubric

      Performance assessments utilizing rubrics to evaluate student work can be beneficial to students and facilitators alike (Trigwell, 1992). The rubric is designed to focus on the important features of a curriculum area. It can be modified to evaluate a wide variety of responses in just about any curriculum area. Below is a sample rubric, which was designed for scoring writing assignments (Exhibit A).

<p align="center">RUBRIC FOR SCORING WRITING ASSIGNMENTS</p>

3	The written response is complete. It indicates a very good Understanding of the story (problem) and provides relevant details.
2	The response is partial and indicates a fairly good understanding of the story. Although the information selected includes mostly accurate details, some may be irrelevant or unrelated to the story.
1	The response is fragmentary and indicates only minimal understanding of the story. It includes mainly random details and irrelevant information.
0	There is little or no response. Inaccurate and irrelevant details indicate a serious misunderstanding of the story.

<p align="center">Exhibit A</p>

Whichever type of rubric an instructor develops, it is important to reveal and explain the criteria to the students before they begin the course work. Advance

knowledge of the expectations will reduce anxiety and allow the student ample preparation time. This will result in improved student work performance.

The design of a rubric incorporates a table with numerical ratings and explanations of the characteristics of each number on the rating scale. With practice, scoring becomes a quick and reliable task, but there are some items that should be considered about the process. First, when evaluating a student's response, refer to the rubric frequently. Additionally, a determination regarding which descriptions best match the student's work must be made. However, there is a possibility that some variations in performance may occur. For example, some students' work performance might be a high 3, others a middle 3, and some a low 3. For this reason, it may improve the process by using pluses or minuses to make finer distinctions. Whichever scoring system is employed, it is important to focus only on the criteria in the rubric and avoid comparing students' work.

Portfolios

The U.S. Department of Education published an article, (Student Portfolios: Classroom Uses, 1993), which defines portfolios as collections of student work representing a selection of performance. They serve to showcase students' accomplishments and works. A portfolio may be a folder containing a student's best works as well as the student's evaluation of the work completed. It may also contain one or more works-in-progress that illustrate the creation of a product as it evolved through the various stages of conception, drafting, and revision. The design of a Student Portfolio is a flexible framework that allows for

many different forms of organization. What works well in one setting may not

work well in another. Therefore, the actual form of the portfolio is likely to vary

from one place to another and from student to student. Designs of the Portfolio

may include: three-ring binders; folders; videos; diskettes; or other formats.

The article also reported that because portfolios are very useful and

flexible, more teachers have recently begun using them in all curricular areas.

Portfolios are useful as a support to new instructional approaches that

emphasize the student's role in comprehension and the teacher's role in

promoting understanding. In addition, a portfolio can be a record of the activities

undertaken over time in the development of their products. It can be used to

support cooperative teaming by offering an opportunity for students to share and

comment on each other's work. Portfolios can also be used to evoke a critical

evaluation of each student's works at various points during the school year.

Recent changes in education policy, which emphasize greater teacher

involvement in designing curriculum and assessing students, have also been an

impetus to increased portfolio use (Student Portfolios: Classroom Uses, 1993).

Portfolios are valued as an assessment tool because, as representations of

classroom-based performance, they can be fully integrated into the curriculum.

Unlike separate tests, they supplement rather than take time away from

instruction. Moreover, many educators and researchers alike believe that

portfolio assessments are more effective than the "old-style" tests for measuring

academic skills.

Portfolios capitalize on students' natural tendency to save work and become an effective way to get them to take a second look and think about how they could improve future work.

Although there is no single correct way to develop portfolio programs, in all of them students are expected to collect, select, and reflect. In building a portfolio, students generate criteria for good work, with teacher and peer input. Students need specifics with clear guidelines and examples to get started on their work, so these discussions need to be well guided and structured. The earlier the discussions begin, the better.

While portfolios were developed on the model of the visual and performing arts tradition of showcasing accomplishments, portfolios in classrooms today are a highly flexible instructional and assessment tool, adaptable to diverse curricula, student age/grade levels, and administrative contexts. For example, the content in portfolios is built from class assignments and as such corresponds to the local classroom curriculum. Portfolios may be developed to focus on a single curricular area--such as writing, mathematics, literature, or science--or they may be developed to span two or more subjects, such as writing and reading, writing across the curriculum, or mathematics and science. Still others span several course areas for particular groups of students, such as those in vocational-technical programs (Student Portfolios: Classroom Uses, 1993).

The age or grade level of students may determine how portfolios are developed and used. For example, in developing criteria, older students are

more likely to be able to help determine the criteria by which work is selected, perhaps through brainstorming sessions with the teacher and other students. Younger students may need more directed help to decide on what work to include. Older students are generally better at keeping logs to report their progress on readings and other recurrent projects. Also, older students often expand their portfolios beyond written material to include photographs or videos of peer review sessions, science experiments, performances, or exhibits.

All portfolios, across these diverse curricular settings, student populations, and administrative contexts, involve students in their own education. Therefore, the student takes charge of their personal collection of work, reflect on what makes some work better, and use this information to make improvements in future work.

Research shows that students at all levels see assessment as something that is done to them on their classwork by someone else. Beyond "percent correct," assigned letter grades, and grammatical or arithmetic errors, many students have little knowledge of what is involved in evaluating their classwork. Portfolios can provide structure for involving students in developing and understanding criteria for good efforts, in coming to see the criteria as their own, and in applying the criteria to their own and other students' work.

Research also shows that students benefit from an awareness of the processes and strategies involved in writing, solving a problem, researching a topic, analyzing information, or describing their own observations. Without instruction focused on the processes and strategies that underlie effective

performance of these types of work, most students will not learn them or will learn them only minimally. Without curriculum-specific experience in using these processes and strategies, even fewer students will carry them forward into new and appropriate contexts. Portfolios can serve as a vehicle for enhancing student awareness of these strategies for thinking about and producing work for both inside and beyond the classroom.

However, good portfolio projects do not happen without considerable effort on the part of teachers and administrators. Research shows that portfolios place additional demands on teachers and students as well as on school resources. Teachers need not only a thorough understanding of their subject area and instructional skills, but also additional time for planning, conferring with other teachers, developing strategies and materials, meeting with individual students and small groups, and reviewing and commenting on student work. In addition, teachers may need extra space in their classrooms to store students' portfolios or expensive equipment such as video cameras. Even so, some teachers have characterized portfolios as a worthwhile burden with tangible results in instruction and student motivation (Student Portfolios: Classroom Uses, 1993).

CHAPTER 3

Research Methods

This study identified alternative methods of assessing adult learners in technical and vocational machine tool programs at MATC. The focus of the study was concentrated on determining ways to improve student evaluation and feedback for the machine tool instructor.

This chapter describes the research design that was used to collect historical data related to alternative assessment of adult learners. There was a vast amount of research data available pertaining to these areas of interest. The data was collected and categorized by assessment method types, such as, essays, oral exams, rubrics and the various other methods. Then competency application types, such as mathematics, critical thinking, problem solving, and other competencies identified the data. This collection of research data also identified the advantages and disadvantages of each assessment method that was selected. The research was followed by a survey of MATC Instructors currently in the machine tool programs. The population, samples, and research schedule of this study were also included in this chapter.

Research Design

The design of this research was based on a review of literature and a survey of the Machine Tool Instructors at MATC. The review of literature included research that had been developed in the areas of alternative assessment methods, adult learning characteristics, and the effectiveness of these alternative methods in vocational education. Because there was a

significant amount of research data, a thorough comparison of the research results from different studies strengthened the validity of the conclusions as they related to the study. This research yielded a list of alternative assessment methods that are best suited for adult learners in Machine Tool programs. The intent of the research design was to chart the alternative assessment methods with the corresponding technical and performance applications.

Population

The population for this study consisted of approximately 75 MATC Instructors employed in the Technical & Industrial Division.

Samples

The sample size was reduced to 12 MATC instructors. They included only MATC Machine Tool Instructors that were State of Wisconsin Technical College System (WTCS) certified and experienced to teach in an MATC machine tool program at the time of the survey.

Instrumentation

The data for this study was collected at the University of Wisconsin-Stout library through their Pubcat system utilizing the ERIC and EDUC indexes. Extensive past research in the areas of assessment, alternative assessment, and adult learners yielded an immense information pool from which the data was collected.

In order to efficiently evaluate and organize this enormous amount of data, a collection method was designed, which facilitated the organization and categorization of pertinent data. The categories included competency skills to be

measured, alternative assessment methods used to measure the competencies, and adult learner characteristics.

The study concentrated on collecting and evaluating research and survey data that fit the needs of the adult students enrolled in machine tool programs at MATC.

Research Data

Type of assessment method and type of skill or performance to be assessed categorized the data. The initial search of articles from 1992 through 1997 yielded over 20,000 articles that dealt with assessment. This was then reduced to approximately 8,000 articles that focused on alternative assessment methods. When "adult learner" was added to the title, approximately 700 articles were matched. The articles were then evaluated for relevance to this particular study.

Chapter 4

Data Analysis

This study identified alternative methods of assessing adult learners in technical and vocational machine tool programs at MATC. The focus of the study was concentrated on determining ways to improve student evaluation and feedback for the machine tool instructor.

Research Questions

This study answered the following research questions:

1. Which alternative assessment methods are used in post-secondary vocational education?

2. Which alternative assessment methods are best designed for post-secondary adult learners in vocational education?

3. Which alternative assessment method is appropriate under which conditions?

Analysis of Results

This chapter presents the results of this study and lists the typical forms of assessment that were used according to the research and survey. Also included is the MATC survey results chart.

Over the past 20 years much has been published on higher education regarding the relationship between assessment and learning. Research in this field has revealed some important factors that need to be considered before developing assessment methods for any curricular area (Trigwell, 1992). These factors include the following:

1) Students are assessed on matters that are easy to assess and thus lead to an over-emphasis on memory and lower-level skills. Creating questions, which test higher order skills, is not impossible, but it demands a degree of professional commitment to the test design.

2) Assessment encourages students to focus primarily on those topics that are assessed. In other words, assessment tasks define the syllabus, and, if students want to get good marks, they focus on these aspects at the expense of others which may capture their interest.

3) The nature of assessment tasks influenced the approaches to learning which students adopt. Not only does the content of assessment define what is to be studied, but also, the kind of task required shapes the learning strategies of students. For example, if students perceive reproduction of information to be rewarded, they will emphasis memory work, and if they see problem solving emphasized, they will tend to practice solving problems.

4) Students who perform well in university examinations can retain fundamental misconceptions about key concepts in the subjects that they have passed. Some of the most profoundly depressing research on learning in higher education has demonstrated that successful performance in examinations does not even indicate that students have a good grasp of the very concepts which staff members believed the examinations to be testing.

5) Students give precedence to assessment, which is being graded. Grading acts as a kind of currency indicating what teachers value. It is in the best interest of students to focus on those things which produce the greatest return.

6) Successful students seek cues from teachers to enable them to identify what is important for formal assessment purposes. Students that are effective performers often use the strategy of attending lectures in order to obtain cues about what matters in a given subject. They focus their energies on these cues and may spend significantly less time studying than their less successful peers.

These findings indicate effects, which are contrary to those which are typically sought. Students are discouraged from taking initiatives beyond their lecturer's interpretation of the syllabus, and they spend their time "sweating for examinations" rather than trying to internalize and make sense of the subject. Evidence such as this suggests that very great care must be exercised in the selection and implementation of assessment tasks, otherwise they can have counter-productive results.

Research Question #1

What alternative assessment methods are used in post-secondary vocational education?

The research and survey discovered that there are various alternative assessment methods, which are applicable to the various situations that may be encountered in education. The more widely used alternative assessment

methods included:

1) Essays

2) Multiple Choice Questions

3) Short Answer Questions

4) Oral examination

5) Peer Assessment

6) Revealed Examination Questions

7) Take Home Examinations

8) Reports

9) Group Work

10) Project Work

11) Portfolios

12) Mastery Tests

Research Question #2

Which alternative assessment methods are best designed for post-secondary adult learners in vocational education?

The research data that was reviewed revealed various assessment methods that ranged from simple to complex. The MATC Machine Tool Instructors were surveyed to determine which assessment methods they have used in various situations (Exhibit B). The MATC survey also revealed similar assessment methods. The survey responses were reviewed, compiled, and then listed in chart form. The research data and the survey results were compared to determine which assessment methods matched each other.

MATC SURVEY CHART

SKILL / KNOWLEDGE TO BE ASSESSED	ASSESSMENT METHOD	PERCENT USED
1. Technical Mathematics	a. Paper Test*	75%
	b. Projects	67%
	c. Take Home Examinations	25%
2. Blueprint Reading	a. Paper Test *	75%
	b. Projects	67%
3. Inspection Measurement	a. Paper Test *	83%
	b. Projects	83%
4. Machine Technology	a. Paper Test *	75%
	b. Projects	75%
5. Machine Setup and operation	a. Projects	100%
	b. Oral Examination	42%
	c. Portfolios	25%
	d. Peer Evaluation	17%
	e. Check List	17%
	f. Paper Test*	17%
	g. Rubrics	17%
	h. Self Evaluation	8%
6. Critical Thinking	a. Projects	92%
	b. Oral Examination	42%
	c. Paper Test *	17%
7. Problem Solving	a. Projects	92%
	b. Oral Examination	42%
	c. Paper Test *	17%

* Paper Tests include: Multiple Choice Questions, Short Answer, or Reports

Exhibit B

The survey revealed that in all situations the instructors applied a variety of

assessment methods to evaluate and receive feedback from their students.

The MATC survey results and the literature research findings both indicated that there were various assessment methods that could effectively work in any situation. Also, they indicated that it was more effective to apply a number of assessment methods whenever feasible.

<u>Research Question #3</u>

Which alternative assessment method is appropriate under which conditions?

The survey and research findings clearly indicate that each curricular area of MATC's machine tool program can be assessed by most of the assessment methods that have been identified. However, it is also clear that some assessment methods may result in higher performance for a specific situation. Also, the findings indicate that it is more appropriate to apply a variety of assessment methods in all situations. This increases the probability of effectively evaluating students and gauging instructor performance.

Projects appear to be a method that can appropriately assess machine tool students effectively and they easily facilitate the incorporation of various other assessment methods. In the machine setup and operation courses project work is essential.

Portfolios are an extension of the project work that students complete. They also facilitate the blending of various assessment methods into the process. A portfolio also has the added benefit of assisting the student in future situations such as reference for continued education and employment interviews.

The rubric is a very versatile assessment tool that can be tailored to fit all machine tool situations. It helps eliminate any confusion about what is expected and serves as a guide during the course work.

Group work in some situations may be a necessity due to lack of resources such as materials, machines, or computers. It may also be helpful in situations where time is limited. Group work can also help develop teamwork, which plays a vital role in the success of company goals.

The various other assessment methods are also appropriate and should not be discounted because of their limited contribution to the students' development. When they are combined with project work for example, they create a more complete and fair assessment.

CHAPTER 5

Summary, Conclusion, Recommendations

This chapter begins with an analysis and a summarization of the information gathered in this study to provide answers for each of the three research questions. Conclusions will be drawn, followed by recommendations.

This chapter specifically identifies recommendations, which can be extremely beneficial to the adult learners returning to post-secondary vocational education, in this case the machine tool students at MATC.

These recommendations from the survey in machining operations, coupled with the research conducted, indicated a diverse approach to alternative assessment is in the best interest of the student and the facilitator. A review of these recommendations and issues affecting their implementation is included.

It is evident from the research that a diversified approach in strategies for alternative assessment is needed. Benefits of a diversified approach include a sense of fairness in the learning individual with respect to grading and evaluating methods. Additionally, utilizing a diversified approach will inherently by nature provide a gain in efficiency when this approach is objective in its implementation.

Research Question #1

Which alternative assessment methods are used in post-secondary vocational education?

The research and survey revealed that there were various alternative assessment methods, which were applicable to these various situations.

The following list includes the assessment methods that were examined

from the research and survey and found to be applicable to post-secondary

vocational education at the time of this study:

1) Project Work

2) Multiple Choice Questions

3) Short Answer Questions

4) Oral examination

5) Peer Assessment

6) Self Evaluation

7) Take Home Examinations

8) Reports

9) Group Work

10) Check List

11) Portfolios

12) Mastery Tests

Research Question #2

Which alternative assessment methods are best designed for post-secondary

adult learners in vocational education?

When the research and survey findings were reviewed, both indicated that

there are various assessment methods that can effectively work in any situation.

Also, they indicated that it is more effective to apply a number of assessment

methods whenever feasible. Additionally, the effectiveness of these methods is

dependent on various factors. These factors include availability of adequate

resources, design time, and maintenance time.

The methods that require a greater amount of resources, design time, and maintenance time include: Project Work and Portfolios. The other various methods which can range from medium to low in resources and time include: Group Work, Reports, Multiple Choice Questions, Short Answer Questions, Oral Examination, Peer Assessment, Self Evaluation, Take Home Examinations, Mastery Tests, and Check Lists.

These assessment methods each were determined to be appropriate for post-secondary adult learners in vocational education.

Research Question #3

Which alternative assessment method is appropriate under which conditions?

The research and survey revealed that in all situations it was more effective for the student and the instructor to apply a variety of the assessment methods that have been identified.

These findings clearly indicate that each area of the machine tool program can be assessed by most of the assessment methods previously discussed. However, it is also apparent that some assessment methods will yield higher results and benefits for a specific situation. Also, the findings indicate that it is more appropriate to apply a variety of assessment methods in all situations in order to fairly and effectively evaluate student and instructor performance. It is equally important to evaluate each situation in order to determine how frequent assessments are required in order to avoid over-assessing.

In order to best describe and reference these findings, a reference chart was created (Exhibit C). This chart lists the items to be assessed and details the

assessment methods that are recommended for each. The assessment methods for each item are listed in order of the first-to-last recommended choice. Also included are the amount of resources, design time, and maintenance time for each assessment method.

Conclusion

There are two major reasons for assessing individuals in pursuit of educational goals. The first reason is a summative type assessment, which is used for grading purposes. This summative assessment is used to determine the student's performance level relative to skills, knowledge and abilities.

The second reason is a formative type assessment, which provides a method for receiving feedback of the students' progress in achieving their goals or objectives.

These two forms of assessments each have a totally different impact on the students. In the case of formative assessment, or assessment for learning, it directly serves the needs of the students. The other involves an assessment for the record or summative assessment, which primarily serves the needs of the outside world (for example, certification of achievements, diploma, and so forth).

ASSESSMENT REFERENCE CHART

Item To Be Assessed	Assessment Method Selections	Resource Requirement Amount	Design Time Amount	Maintenance Time Amount
Technical Mathematics	1. Mastery Tests	Low	Medium	Low
	2. Projects	High	High	High
	3. Paper Tests*	Low	Medium	Low

	4. Rubrics	Low	Medium	Low
	5. Portfolios	High	Medium	High
Blueprint Reading	1. Mastery Tests	Low	Medium	Low
	2. Projects	High	High	High
	3. Rubrics	Low	Medium	Low
	4. Portfolios	High	Medium	High
Machine Technology	1. Mastery Tests	Low	Medium	Low
	2. Projects	High	High	High
	3. Paper Tests*	Low	Medium	Low
	4. Portfolios	High	Medium	High
Critical Thinking	1. Projects	High	High	High
	2. Mastery Tests	Low	Medium	Low
	3. Paper Test *	Low	Medium	Low
	4. Oral Exams	Low	Medium	Low
Problem Solving	1. Projects	High	High	High
	2. Mastery Tests	Low	Medium	Low
	3. Paper Test *	Low	Medium	Low
	4. Oral Exams	Low	Medium	Low
Inspection Measurement	1. Projects	High	High	High
	2. Mastery Tests	Low	Medium	Low
	3. Portfolios	High	Medium	High
	4. Rubrics	Low	Medium	Low
	5. Group Work	Low	Medium	Medium
	6. Peer Evaluation	Low	Medium	Medium
Machine Set-Up and Operation	1. Projects	High	High	High
	2. Mastery Tests	Low	Medium	Low
	3. Portfolios	High	Medium	High
	4. Rubrics	Low	Medium	Low
	5. Group Work	Low	Medium	Medium
	6. Peer Evaluation	Low	Medium	Medium

* Paper Tests can include: Multiple Choice Questions, Short Answer, or Reports

Exhibit C

The alternative assessment methods described in this study can effectively work for either case. Both reasons for assessing are equally important to the students. However, formative assessment has a greater impact on the instructor because it gauges performance of both the student and the instructor throughout the entire course.

Recommendations

The research and survey results indicate that an innovated approach is fundamental to the development of an effective assessment plan. Therefore, the researcher has developed the following recommendations:

Recommendation 1

Begin the assessment process by identifying the skills or knowledge to be assessed. Select the assessment methods from the reference chart that are recommended for each skill or knowledge to be assessed. A minimum of three assessment methods should be implemented for each item.

Project work facilitates all the items to be assessed and can incorporate various other assessment methods into it. Therefore, it is more advantageous to implement project work whenever it is feasible to do so.

When project work is to be implemented, it is important to determine what resources and how much time are available. The project work should start with something at the beginner level and gradually introduce more advanced level work. The design and implementation of the projects should focus on achieving the course objectives and outcomes.

Recommendation 2

The rubric is a flexible assessment tool that can be tailored to the needs of the particular situation that it will evaluate. Therefore, it is recommended that a rubric design be utilized. The rubric can vary in design type, as well as, the items that it includes.

However, an effective rubric should include an adequate description of the items and sufficient evaluation criteria. Additionally, it should include a scoring range for each grade. For example, Exhibit D describes a recommended rubric design for assessing project work of machine shop students.

Recommendation 3

The factors that are required for each individual assessment method are crucial to its successful implementation. Therefore, it is recommended that implementation of an assessment method is avoided until sufficient resources, design time and maintenance times are available. Also, avoid implementing more assessment methods than can be effectively maintained and evaluated.

Recommendation 4

It is important to determine if an assessment method is properly designed to evaluate the required items. Therefore, it is recommended that a method of receiving feedback, such as an evaluation form of the assessment methods that are used be developed. This feedback form will assist in modifying and correcting any problem areas of the assessment design. The feedback will also assist in the development of future assessment implementations.

Machine Shop Project Evaluation

Student Name:_____ Date:_____

Description	Score=0	Score=1	Score=2	Score=3
1.) Safety: Machine Shop Operations	Not safety conscious	2 Unsafe Incidents	1 Unsafe incident	0 Unsafe incidents
2.) Class Participation	Does not display any	Displays minimal	Displays a willingness to	Shares ideas, & cooperates

& Teamwork	cooperation	cooperation	cooperate	effectively
3.) Setup & Operation	Does not follow instructions	Follows instructions 75% effective	Follows instructions 90% effective	Follows all instructions effectively
4.) Project Completion; All Required Materials	Materials are Incomplete	Materials are complete and 75% accurate	Materials are complete and 88% accurate	Materials are complete and 92% accurate
5.)Technical Mathematics	Calculations are not correct	Calculations are 70% correct	Calculations are 88% correct	Calculations are 92% correct
6.) Blueprint Reading	Does not evaluate blueprints	Evaluates blueprints 75% correctly	Evaluates blueprints 88% correctly	Evaluates blueprints 92% correctly
7.) Problem Solving	Does not Identify the problem	Identifies and solves 75% of problems	Identifies and solves 90% of problems	Identifies and solves problems
8.) Critical Thinking	Does not use critical thinking	Uses critical thinking 75% effectively	Uses critical thinking 90% effectively	Uses critical thinking effectively
Total Score:	_____	_____	_____	_____

Score = Grade: 22-24=A   19-21=B   16-18=C 10-15=D 0-9=F

Exhibit D

Recommendation 5

The assessment methods identified in this study are appropriate for assessing the various situations encountered in a machine tool program. Their successful selection and implementation is dependent on careful consideration of all the previously mentioned factors. However, no limitation should be implied when considering which assessment methods are appropriate.

Therefore, it is recommended that other creative ideas be considered to determine their effectiveness in assessing any machine tool program situation. Another approach that may yield other assessment methods not reported in this study is to network with other technical school and college instructors. This will also assist in revealing any future developments in assessment that have not yet been reported.

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