WORKPLACE SKILLS AND THE SKILLS GAPS
RELATED TO EMPLOYEE CRITICAL THINKING ABILITY
AND SCIENCE EDUCATION CURRICULUM

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

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*****

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ABSTRACT

In recent years, business and industry have been vocal critics of education. Critics complain the American workforce, particularly young people, are deficient in workplace skills.

A survey of 500 randomly selected Ohio businesses was used to determine opinions of respondents related to workplace skills gaps, rising skill levels, and level and type of critical thinking used on the job by all employees and entry-level employees. Four of 18 science outcomes promoted by the Ohio Department of Education had an application in business and these required critical-thinking skills to complete. These four formed the foundation in the survey because they provided a connection between thinking skills required on the Ohio 12th Grade Proficiency Test and those required on the job.

Pearson correlation coefficient was used to identify correlation between responses. The alpha level was $p \leq .05$. Stepwise multiple linear regression analysis was conducted to identify significant ($p \leq .05$) relationships between variables as represented by responses. In addition, one version of the Science Section of the Ohio 12th Grade Proficiency Test was analyzed for use of critical thinking using the SCAN’s critical-thinking attributes as a standard.
There were several findings related to workplace skills and critical thinking. Only 17.1% of respondents indicated dissatisfaction with the basic academic skill level of their employees. A majority (71.1%) of responding businesses perceived a lack of work ethic as more important than deficient academic skills. Only 17.1% of respondents reported the skill level of their entry-level employees was rising. Approximately 1/3 of responding businesses required no critical thinking at all from their entry-level employees. Small businesses were significantly more likely to require higher levels of critical thinking from their entry level employees than larger businesses. Employers who reported rising skills in entry-level employees required all of their employees to exhibit critical thinking similar to that required on the four tested outcomes on the Science Section, Ohio 12th Grade Proficiency Test.
Dedicated to the memory of my father and mother, both Ohio State graduates
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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

A sound foundation in science is thought to benefit an individual in two major ways. First, a person is thought to have a richer and fuller life if he or she has an appreciation and an understanding of the principles of science. Secondly, many believe a sound science education will make a person more employable and more successful on the job. It is this second benefit which is of interest in this study.

In recent years, business and industry have been vocal critics of education. Many sources in business have indicated they believe there is a gap between the academic skill level, including science, of graduating students and the level of expertise expected and required by employers as these individuals enter the workforce (Department of Labor, 1991, 1992; Ohio Department of Education & Ohio Business Roundtable, 1998). The preparation and readiness of students as they enter the working world has become an area of intense study and reform. The skills gap issue, many believe, has serious implications for the economic future of the United States (US).

It has become a very confusing topic. Confusion exists over how skills are defined, what skills are desirable in the workplace and to what depth they are needed, whether or not there is a deficiency in necessary skills, and what role schools play, or should play, in facilitating skill acquisition.
Much of the rhetoric centers on the idea of a dynamic global economy and the resultant changes industry must make if American economic power is to remain at a world-class level. A great deal has been written about the wrenching adjustment American companies have had to make to compete with foreign products and about those workers who have been fired due to plant closings or relocations. In the late 70s and early 80s many domestic products were judged inferior compared to those of other countries, especially Japan. Reports the last few years, however, indicate that adjustments in attitudes, processes, and products by American companies have mostly been successful in increasing the quality and desirability of domestic products. Even a new style of management is becoming more common. American companies are often now described as lean and mean and quite capable of competing with the best foreign firms. There is a general good feeling about our economic future and a new found respect and even admiration for American business enterprise.

Arising from this positive view of American economic competitiveness, however, are concerns that our schools have not kept up with these needs. Critics complain that the US workforce is deficient in some skills, particularly those of young people just entering the workforce. Educators demonstrate a consensus “that acquisition of workplace skills and career development competencies are an important part of the secondary school experience” (Barker & Satcher, 2000, p. 134). Great concern is being expressed that our economic future is threatened by the lack of qualified employees. Some critics go so far as to suggest the United States will not be able to compete in international markets and may even become a second rate economic power unless something is done to improve the skills of workers (Carnevale, 1989; Carnevale, Gainer, Meltzer, & Holland, 1988; Clinton, 1987; Joyce & Voytek, 1996; “Money Talks”, 1996; Packer, 1992). There are frequent accounts in the media stating employers lament over the poor quality of their new-hires (Gordon, 1990; Jones, 1996; Townley, 1989; Woodhead, 1996) and some even
are expressing that lack of worker quality prevents them from developing new products and from entering new markets (Davis, 1995; Kopp, 1998).

Our culture seems to have a tendency to assign blame whenever mistakes are made or deficiencies found. And so who is to blame for this low skill level of workers? Many hold the schools accountable for the perceived low level of skills of graduates. It has now been twenty-one years since *A Nation at Risk* (National Commission on Excellence in Education, 1983) was first published suggesting our schools are not providing a quality education of our youth. With the publicity given to workplace skill deficiency, schools have been blamed, and continue to be blamed, for ill preparing young people to enter the job market. It is pointed out that business is changing rapidly, but the schools are not changing fast enough.

One of the specific skill deficiencies often mentioned in research is critical thinking (CT) (Carnevale et al., 1988; Department of Labor, 1991, 1992; O’Neil, Allred, & Baker, 1992a). Studies (Carnevale, 1989) indicate that the changing business climate and management style necessitates workers to accept more power and control in the workplace. There are less managers and layers of management in many companies than in the past. With the employees making more decisions affecting the profitability of the company, employers often say they want workers adept at critical thinking (Oklahoma Department of Vocational and Technical Education, 1994; Santry, 1996). Critical thinking (CT) has widely been accepted as a vital part of a good education yet employers state dissatisfaction with the thinking ability of graduates (Carnevale et al., 1988; Department of Labor, 1991, 1992). Despite much discussion, no clear answer to the workplace skills issue has emerged.

The skills required of employees and those of students in the classroom are not as different as some may believe. Much of what is required of employees is parallel to that required of students. Table 1 illustrates required skills common to both groups.
Table 1

*Workforce skills demonstrated by students in the classroom*

<table>
<thead>
<tr>
<th>Workforce Skill</th>
<th>Factor Affecting Skill</th>
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<td>Oral communication</td>
<td>Employees communicate with management and other employees on products/process</td>
<td>Students communicate with teachers and other students concerning learning outcomes</td>
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<td>Written communication</td>
<td>Employees must write memos and draft reports</td>
<td>Students demonstrate mastery of content mostly by written communication</td>
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<td>Dependability</td>
<td>Employers require good attendance and completion of assigned tasks</td>
<td>Educators require good attendance and completion of assigned tasks</td>
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<tr>
<td>Self-direction</td>
<td>Employers require most employees to work independently on some tasks</td>
<td>Educators require students to work independently on some tasks</td>
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<tr>
<th>Skill</th>
<th>Employee Requirements</th>
<th>Student Requirements</th>
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<td>Teamwork</td>
<td>Some tasks require employees to function as a member of a team</td>
<td>Collaborative learning requires students to work as a member of a team</td>
</tr>
<tr>
<td>Time management</td>
<td>Many employees responsible for organizing schedules and meeting deadlines</td>
<td>All students responsible for organizing time and meeting deadlines</td>
</tr>
<tr>
<td>Critical thinking</td>
<td>Some employees required to make decisions on what to believe</td>
<td>All students required to think critically on some activities</td>
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**Note.** Student skills represent those required of students in progressive classrooms using a variety of accepted teaching and learning techniques.

The comparisons in Table 1 might surprise those who feel a student’s work in school is unrelated to what he or she will later be required to do on the job. It seems reasonable that a young person exhibiting competence in the categories listed in Table 1 should be able to make the transition to the working world with a minimum of difficulty.
1.2 Need for the Study

Ohio businesses and educators have great interest in this subject. Several surveys (Carnevale et al., 1988; Department of Labor, 1991, 1992; Ohio Department of Education & Ohio Business Roundtable, 1998; O’Neil et al., 1992a) have listed specific worker skills that employers have said are necessary if their firms are to remain competitive. However, considerable disagreement exists over what skills are important and necessary. Additional debate occurs about what the schools should be doing to improve the skill level of students. The Ohio proficiency tests have been developed to provide some measurement of academic achievement and accountability to the Ohio taxpayers and employers.

It is expected that the results of this study may provide useable information in several areas. The results may give a clearer picture of what Ohio employers require of entry-level workers, particularly in reference to critical thinking and may measure the depth of critical thinking used in Ohio workplaces. The results may indicate correlation between the critical thinking required on the job and that required to answer the questions of the science segment of the Ohio 12th Grade Proficiency Test.

1.3 Purposes and Objectives

This study has three purposes and seven objectives.

The purposes of the study are the following:

1. to make recommendations to Ohio educators concerning the level of critical thinking required of entry level employees in Ohio businesses.
2. to provide information for decision making concerning future Ohio Science Standards.
3. to make recommendations to strengthen science curricula.
The research objectives are the following:

1. to determine how often Ohio employers require their entry-level employees to use critical-thinking tasks that are also required on the Ohio 12th Grade Proficiency Test.
2. to determine how often Ohio employers require all employees to use critical-thinking tasks that are also required on the Ohio 12th Grade Proficiency Test.
3. to identify differences in critical thinking required of Ohio employees in five geographic regions of the state.
4. to identify differences in critical thinking required of Ohio employees in various business categories.
5. to determine the number of Ohio businesses requiring testing for critical thinking as part of their pre-employment screening.
6. to determine the number of Ohio businesses which face the need for an increase in the skill level of their entry-level employees.
7. To determine the level of critical thinking required of Ohio entry-level employees.

1.4 Statement of the Problem

The study aims to answer the following major research questions:

1.4.1 Descriptive Questions

1. Are there geographical differences in the critical-thinking requirements of businesses in Ohio?

2. Are there differences in critical thinking required on the job by different types of businesses in Ohio?
3. What is the depth of critical thinking required in Ohio businesses?

4. What percent of Ohio businesses sampled are high-performance workplaces?

1.4.2 Quantitative Questions

1. Is there a correlation between critical-thinking tasks needed on the Ohio 12th Grade Proficiency Test Science Section and those required on the job by Ohio entry-level employees?

2. Is there a correlation between critical-thinking tasks needed on the Ohio 12th Grade Proficiency Test Science Section and those required on the job by all Ohio employees?

3. What percent of Ohio businesses sampled test for critical-thinking ability during pre-employment screening?

4. What proportion of Ohio businesses face an increase in the required skill level of their entry-level employees?

1.5 Assumptions

1. The respondents will understand the survey questions and will answer the questions honestly.

2. The version of the 12th Grade Proficiency Test Science Section analyzed in this study is similar to other versions used by the State of Ohio.

3. The sample taken from advertisers in the Yellow Pages is representative of the population of Ohio businesses.

4. The definitions of basic skills and work ethic are consistent among respondents.
1.6 Delimitations

1. The study considered only four learning outcomes that use critical thinking out of the 18 included in the Science Section of the Ohio 12\textsuperscript{th} Grade Proficiency Test for critical thinking analysis by survey respondents. These four outcomes have application in a business setting, the other 14 do not.

2. The study considered only the Science Section of one version of the Ohio 12\textsuperscript{th} Grade Proficiency Test.

3. Only businesses which advertised in the Yellow Pages were eligible for random selection as part of the sample.

1.7 Limitations

1. The survey is based on a sample and is subject to sampling error. Responses from participants may not exactly reflect the population.

2. The study contains self-reported survey data. Therefore, it is subject to the limitations associated with the use of self-reports.

3. Results cannot be generalized beyond the State of Ohio since the population was restricted to Ohio businesses.

4. Survey response rate was less than 100 percent of the sample.

5. Respondents might have had differing concepts of some survey terminology such as basic skills and work ethic.
1.8 Descriptive Tasks

1. To determine the frequency of Ohio businesses exhibiting characteristics of the new-management style
2. To discern the levels of critical thinking required of employees on the job
3. To determine if the Global Economy has affected the employee skill-level requirements in Ohio businesses
4. To assess Ohio employer beliefs about the work force readiness of entry-level employees
5. To determine the frequency and types of critical thinking required to successfully complete the Science Section of the Ohio 12th Grade Proficiency Test.

1.9 Research Hypotheses

1. There is a significant difference between critical thinking used on the job and the size of the business.
2. There is a significant difference between critical thinking used on the job and the type of business.
3. There is a significant difference between critical thinking used on the job and business location.
4. There is a significant difference between critical thinking used on the job and the critical thinking required on the Science Section of the Ohio 12th Grade Proficiency Test.
5. There is a significant positive correlation between those businesses exhibiting characteristics of the high-performance workplace and increasing skill levels.
6. There is a significant positive correlation between those businesses exhibiting characteristics of the high-performance workplace and the perception of employees
demonstrating use of critical thinking at the highest level.

7. There is a significant, positive correlation between businesses that require a high level of critical thinking from their employees and the more frequent use of the four proficiency outcomes from the Science Section of the Ohio 12th Grade Proficiency Test applicable to a business setting.

1.10 Summary

Chapter 1 includes the background of the study which touches on the controversy surrounding workplace skills and the pressure on schools to produce better prepared, more work-ready graduates. There is a need to learn more about the labor requirements of Ohio business in order to make sound education decisions at the state and local levels. The statements of the problem, assumptions, delimitations, limitations, and research hypotheses provide the operational core of the study.

Chapter 2 includes nine sections. Section one considers the characteristics of the new economy. Section two provides an explanation of the characteristics of the traditional management style and section three includes a description of the global economy phenomenon that has emerged in recent years. Section four describes the new management style that is associated with the global economy. Section five examines the skills that employers say they need based on the results of several surveys, some national and some regional in scope. Since the study focuses on the critical thinking requirements of business and the critical thinking required on the Science Section of the 12th Grade Ohio Proficiency Test, section six examines the topic of critical thinking in depth. A further examination of critical thinking occurs with the examination of popular critical thinking
tests found in section seven. Section eight includes the problems occurring with the teaching of critical thinking in the classroom. Chapter 2 concludes with an examination of the connection between workplace skills, critical thinking, and science education.
CHAPTER 2

REVIEW OF THE LITERATURE

2.1 The New Economy

The foundation upon which all the studies, surveys, and rhetoric about workplace skills is based is the belief that the American economy is part of the larger global economy and both are in a state of great change. The watchword is competitiveness, not only in this country, but around the world (Davis, 1995). The ability to produce goods and services of high quality and at an attractive price is of great concern. Being competitive means jobs and a good economy. The emergence of the competitive global market is one of the main factors marking the postindustrial era and a major cause of rapid change in the American economy (Allen, 1995; Carnevale, 1992; Carnevale et al., 1988; Magaziner & Clinton, 1992; Marino, 1995; Murnane & Levy, 1997; O’Neil, Allred, & Baker, 1992b; Roberts, 1996). This change manifests itself in several ways. One of the more widely publicized results of the global economy is the shift of labor intensive industries, such as shoemaking, from the United States to countries with lower wage rates. A second result has been consolidations and relocations among American firms intent on lowering costs to compete with imports. Both have resulted in massive worker layoffs and real wage reductions.

A more subtle change has been the need expressed in industry for workers with higher levels of skills than in the past (Carnevale et al., 1988; Davis, 1995; Davis & Miller, 1996; Department of Labor, 1991, 1992; Marino, 1995; “Perspective on
Education in America,” 1993; Roberts, 1996). In order to remain competitive, so the argument goes, employees must function in ways much different than in the past. Downsizing has reduced layers of management such that workers are expected to accomplish more tasks and make decisions that previously were made by supervisors (Carnevale, 1996; Carnevale & Porro, 1994). This has been called the ‘new management’ by some and can also be labeled worker empowerment (Carnevale, 1996). The literature gives many examples of surveys (Carnevale et al., 1988; Department of Labor, 1991, 1992; O’Neil et al., 1992a) done to identify the skills needed now and in the near future and almost always researchers conclude that there is a skills gap between what business demands and what employees can deliver. It is important to understand the change in management style and its effect on the workplace.

The introduction to this study touched on what is described as an increased need for employees with greater ability to think critically on the job. This need was pointed out as arising from increasing global competition and a changing management style. It is said that employees will have more control over the workplace and that the layers of management which existed under the ‘old management style’ will disappear (Carnevale, 1996). Employers seem to have a difficult time finding employees with adequate critical thinking skills and often the schools are blamed for failing to produce graduates who can meet the needs of employers. Yet, many employers express concern over the absence of the old fashioned work ethic, giving a day’s work for a day’s pay, or just plain showing up for work. Contradictions exist concerning critical thinking and the future and present employer needs.

Many of the studies share a common concern, that of a changing economy and a changing workforce. The adjustment to a global marketplace has necessitated a rethinking of American approaches to the utilization of people in organizations (O’Neil et al., 1992b). The early part of this century brought a growing concern about the management of individuals in large organizations because of the industrial revolution.
Productivity had previously been regarded as a function of technology and access to raw materials. Fredrick W. Taylor, considered the father of American management, recognized the limitations in skills of most workers in these organizations (O’Neil et al., 1992b). His answer to the deficiency in worker skills was to intensify management structure to supervise workers. This was the dominant American management style for several decades, but has been reconsidered in recent years.

2.2 The Traditional Management Style

In order to understand the new management style, it is important to have a foundation in what it is replacing. The old style, and the dominant, preferred method up until only the last few years, is credited to Frederick W. Taylor (O’Neil et al., 1992b). A former President of the American Society of Mechanical Engineers, Taylor proposed a new management method in the latter decades of the Nineteenth century. His strategy was to emphasize the need for an extensive managerial structure to organize and supervise the workers, leaving as little responsibility and discretion as possible to the common worker (O’Neil et al., 1992b). Taylor (1911) accepted skill limitation in some employees as inevitable; each worker was suited for specific tasks based on the employee’s innate ability. This is illustrated in the following passage from his 1911 book *The Principles of Scientific Management*:

Now one of the very first requirements for a man who is fit to handle pig iron as a regular occupation is that he shall be so stupid and so phlegmatic that he more nearly resembles in his mental make-up the ox than any other type. The man who is mentally alert and intelligent is for this very reason entirely unsuited to what would, for him, be the grinding monotony of work of this character. Therefore the worker
who is best suited for handling pig iron is unable to understand the real science for
doing this class of work. He is so stupid that the word “percentage” has no meaning
to him, and he must consequently be trained by a man more intelligent than himself
into the habit of working in accordance with the laws of this science before he can
be successful (p. 59).

Taylor’s characterization of some laborers as too stupid to understand the nature of
their work and in need of extensive management would be considered insensitive and
archaic today. He stated clearly that he believes some workers do not have the needed
mental capacity, and we could include critical-thinking skills here although the term did
not exist then. Interestingly, he makes no case for ‘retraining’ workers. He accepted their
shortcomings and suggested extensive management to make best use of their abilities.
Yet, one must realize that this was revolutionary in the 1880s and was the “new”
management style then. He called this Scientific Management or task management
(Taylor, 1911).

If Scientific Management was new, what did it replace? Surprisingly, it replaced a
management method by which work is under the control of the employee, the Initiative
and Incentive Method as Taylor (1911) labels it. It is surprising because the ‘new’
management style in the 90s appears to be strikingly similar to what Scientific
Management replaced.

Taylor recognized a conflict in the workplace as employers tried to get the most
effort from their workers. He describes the struggle as follows (Taylor, 1911):

Only those among the readers of this paper who have been managers or who have
worked themselves at a trade realize how far the average workman falls short of
giving his employer his full initiative. It is well within the mark to state that in 19 of 20 industrial establishments, the workers believe it to be directly against their interests to give their employers their best initiative, and that instead of working hard to do the largest possible amount of work and the best quality of work for their employers, they deliberately work as slowly as they dare while at the same time try to make those over them believe they are working fast (p. 33).

The initiative mentioned in the excerpt above is the first part of the Initiative and Incentive management style. The incentive is what management provides to coax the most initiative from workers. Taylor believed that management must provide some special incentive to his men beyond that which is given to the average of the trade (Taylor, 1911). This would be done to increase productivity and profits. The special incentive could take many forms; “the hope of rapid promotion or advancement, higher wages, either in the form of generous piece-work prices or of a premium or bonus of some kind for good and rapid work, shorter hours of labor, better surroundings and working conditions than are ordinarily given, etc.” (Taylor, p. 34). Taylor described this combination of initiative and incentive as the best management style of the day. What bothered Taylor, the mechanical engineer, was that the knowledge of the work, the speed of the work, the quality of the work, and the total amount of work performed was almost totally under control of the worker who, as he perceived, was almost always ‘dogging it’ or in the language of the day, ‘soldering’. This laid-back concept of work apparently goes back more than a few decades. Bridges (1994) writes that in the Middle Ages there was no set time to arrive at work. Workers arrived when they pleased and worked long enough to complete their assigned tasks. They would often not show up for days or
weeks with no repercussions (Bridges). Taylor sought to provide more structure and accountability. He felt productivity, profits, and wages would increase if management took more control of the workplace. He described Scientific Management in the following manner (Taylor):

Under scientific management the initiative of the workman (that is their hard work, their good will, and their ingenuity) is obtained with absolute uniformity and to a greater extent than possible under the old system; and in addition to this improvement on the part of the men, the managers assume new burdens, new duties, and responsibilities never dreamed of in the past. The managers assume, for instance, the burden of gathering together all of the traditional knowledge which in the past has been possessed by the workmen and then of classifying, tabulating, and reducing this knowledge to rules, laws, and formulae which are immensely helpful to the workman in doing their daily work (p. 36).

Most foremen and superintendents rose into management from the ranks of workers and each possessed skills characteristic of his trade, but were mostly ignorant of the finer points of the work done in other trades. This was a weakness Taylor hoped to eliminate when he wrote of classifying, tabulating, and reducing the tasks. He was talking about empowering management.

Scientific management required management to take on new duties, which Taylor (1911) grouped under four headings:

1. Managers develop a science for each element of a man’s work, which replaces the old rule of thumb method.

2. They scientifically select and then train, teach, and develop the workman,
whereas in the past he chose his own work and trained himself as best he could.

3. Managers heartily cooperate with the men so as to insure all of the work is being done in accordance with the principles of the science that has been developed.

4. There is almost equal division of the work and the responsibility between management and the workman. Managers take over all work for which they are better fitted than the workman, while in the past all of the work and the greater part of the responsibility were thrown upon the men (p. 36).

The principles of science of which Taylor spoke in number one above involved an intensive and extensive analysis of each man’s job, studying, in a scientific manner, the movements necessary to do the job, and a realignment of the job so that the individual could produce a maximum quantity of work. “The enormous saving of time and therefore increase in the output which is possible to affect through eliminating unnecessary motions and substituting fast for slow and inefficient motions for the men working in any of our trades can be fully realized only after one has seen the improvement which results from a thorough motion and time study made by a competent man” (Taylor, 1911, p. 24). Near this section of Taylor’s book, some reader from long ago had written in fountain pen, “work’em till they drop”. No doubt this is a reference to what might be considered overworking the employees. The term ‘sweat shop’ was in use those days and Taylor addresses this concern. He felt that sympathy for those overworked, but believed many more were under worked and underpaid (Taylor). By adopting the principles of scientific management, he suggested that the lives of the worker would improve dramatically due to the benefits of a more efficient workplace and higher wages (Taylor). Taylor didn’t have much respect for the common worker’s self-motivation, but he did have a good grasp of
economics. Low productivity results in low wages. Conversely, a highly productive company can afford to pay high wages.

Taylor saw benefits for both worker and manager with higher productivity; greater profits for the company and higher wages, significantly higher wages, for the worker. Taylor suggested wage gains from 30 to 100% were possible with his management style (Taylor, 1911). He uses an example of handling pig iron at Bethlehem Steel at the beginning of the Spanish-American War. There was a large quantity of pig iron that needed to be moved (by hand) into rail cars for transfer to munitions makers. He found the average worker was loading about 12.5 tons of pig iron a day. After studying the requirements of the job, he calculated that a man should be able to load 47 to 48 tons per day. He picked four men, taught them to carry pig iron according to his principles, and they responded by meeting the tonnage goal. The men were receiving 60% more pay than the remaining workers because of their increased production (Taylor).

The above example illustrates the essence of Scientific Management. Management empowers itself to control the workplace by collecting knowledge about each task, by training each worker in the most efficient way of performing the task, and by manipulating wages to encourage employees to work in the way management suggests. This workplace control by management was carried to a new level when Henry Ford first put the assembly line in his River Rouge factories. Now the rate of production could be carefully controlled and the line worker was forced to perform his job quickly in order to keep up.

This is what is labeled the old management. It came into general acceptance decades ago to more efficiently produce goods and services. It was originated by Taylor
to benefit both the company and employees by increasing profits and wages concurrently and generally served this country well if our industrial and social prosperity is the indicator. But recently, many no longer feel “Taylorism” can serve our country in the global economy. Curiously, what many are suggesting in its place is less management and more worker responsibility, which is remarkably similar to what existed before Taylor’s Scientific Management became widely accepted. What was the impetus that caused this shift in another direction?

2.3 Competition Goes Global

Changes began to occur after World War II. Former enemies and allies both rebuilt their industrial base and began to compete with the U.S. At first others tried to emulate the spectacular success of American mass production, but learned quickly that if they mass produced, they would fail (Carnevale, 1996). They simply did not have big enough domestic markets. These companies recognized that they must sell to a variety of foreign markets. Meeting the requirements of this variety of markets required engineering and producing of a mix of products to meet the needs of diverse populations. In addition, foreign firms began to emphasize quality and they located more authority in skilled workers on the line in order to build quality into production systems (Carnevale, 1996). American companies were mass producing what they thought customers should have while foreign firms were finding out what customers wanted and sold it to them. These companies began to gain market share.

Eventually American companies learned from their competitors and adopted many of the same customer oriented policies and there is reason to believe this trend will continue. In short, American business has reorganized (Packer, 1992) and future work
will most likely be heavily customer-based both internally and externally (Santry, 1996). Quality and variety of products are just two of several facets of business success in the global economy. Carnevale & Porro (1994) compare the old and new economies.

In the old economy, institutions were judged on their ability to be productive and efficient: to produce high volumes of standardized goods and services at low prices, thereby giving greater access for an ever increasing share of Americans to everything from toasters to education. In the new economy, access standards have been joined by a more complex set of institutional performance goals in both education and business organizations including:

**Quality** - Meeting the highest professional, client and global standards.

**Variety** - Moving beyond one-size-fits-all by providing diverse goods and services that meets the wants and needs of individual client groups.

**Customization** - Designing user-friendly goods and services and delivery methods.

**Consistency** - Meeting standards in virtually every case while moving toward zero-defect.

**Speed** - Minimizing client time commitments in the consumption of goods and services.

**Continuous innovation** - Getting new ideas off the drawing board and into the hands of clients faster and winning the race up the learning curve by making continuous improvements in goods and services.

**Social responsibility** - Producing and delivering goods and services in a socially responsible way (p. 6).
There are success stories. It is common knowledge that many American companies have improved product quality and become more sensitive to consumers. The American auto industry is the most well known example. Twenty years ago American-made cars were rated well behind the Japanese models, but in the nineties, the gap was narrowed greatly. Today, several American models are judged better than some Japanese cars. Not only quality, but also productivity and cost control have also improved, and the auto industry is not the only example. Leaner, meaner business in general has resulted in higher productivity, more efficient workers, and growing U.S. exports (Roberts, 1996).

A key term for the successful organization is sensitivity. Becoming sensitive to customer demands and desires becomes a major goal of industry. Carnevale (1996) maintains a company must become a learning organization if it is to remain ahead of competition. Institutions have to be capable of learning, of being self conscious of what they are doing. Learning organizations are those where information not only flows from the top down, but where information and knowledge flow freely throughout the institution (Carnevale, 1996). With this free flow of information every worker has the potential to be actively involved with new ideas and product improvements.

One major way of responding to the customer is by adding technology and employers have introduced new technology at a very rapid pace. Computer-based manufacturing technology could measure and meet new quality standards and customize production runs or tailor services with a few keystrokes (Carnevale, 1996). However, companies quickly learned that widely available technology in a company required workers with additional skills (Lewis, 1995). To introduce new technology without trained, or trainable, employees negates what positive affect the new technology may
have. The new work systems require improved worker skills of three kinds (Carnevale, 1996).

Worker Skill Improvements Due to Technology Introduction

1. Competence in basic skills-reading, writing, and arithmetic, and the ability to apply the basic skills.
2. Workers have to know something that makes them of specific value-what the worker can do becomes more important than who the employer is.
3. Behavior skills are more important in the new economy; taking responsibility for final product, interacting with customers (p. 9-10).

2.4 The New Management Style and the New Workplace

The new management style revolves around the idea of fewer layers of management and more empowered workers. Employees are increasingly called upon to make decisions and perform tasks that previously were done by management. Employers have abandoned Frederick Taylor’s 90-year-old assembly line mentality, one that makes little use of employee’s talents, relying on them only to perform repetitive, routine tasks (Packer, 1992). High performance firms have replaced the Tayloristic approach with one advocated by Edward Deming and practiced by the Japanese auto industry and by American firms such as Motorola which has won the esteemed Baldridge award in this country (Packer, 1992). The qualities of high performance that characterize our most competitive companies must become the standard for the vast majority of our employers, public and private, large and small, local and global (Department of Labor, 1991). As a result, companies are coming to expect more from their employees (Carnevale, 1996, 1989; Carnevale & Carnevale, 1994) and these higher expectations have caused a new
workplace to evolve. Many managers have come to recognize a need to have workers take on more responsibility in the workplace if American companies are to remain competitive. Trying to increase productivity to better compete with Japan, Germany, and other top economic powers, top U.S. companies are moving more decisions to the factory floor (O’Neil, 1992). In order to introduce new products and services more rapidly into the marketplace, new directions in management emphasize participative management, less layers of organizational structure, just in time management, and team work (O’Neil et al. 1992b) and this results in greater skill levels in employees than existed previously. The combination of increasing competition in both domestic and international markets, rapid and significant changes in technology, and changes in how the workplace is organized has altered the skills needed in industry (Joyce & Voytek, 1996). Koontz (2000) notes the increase from 20% to 65% of skilled workers demanded in the US economy from 1950 to 2000.

Another area of change in management is the location of the workplace itself. A growing number of individuals are working at home. For example, only a few years ago 10,000 people worked at IBM’s 50 story Chicago headquarters (November, 1996). This was the traditional workplace management style; clear structure of schedules, reporting lines, and physical space. Today, there are only 3500 workers at the home office and eighty percent work out of their homes (November, 1996). At Motorola, forty percent of all workers will work at home (November). Workers are forced to adopt new disciplines and skills as they adapt to the more flexible, but no less demanding and rigorous home work routine. Instead of expecting work to be highly structured and defined, workers will identify their own problems and manage their own productivity. This trend reduces the level of management even more and adds to the level and degree of employee skills required.

In the competitive global economy, the companies that can take an idea and move it to a new product or improve the process the fastest have a competitive advantage over
others. There is a great dependence on the latest technology and the employees who are adept at using it (West, 1995). The old top-down hierarchy or Taylor management style worked well when there was little competition and no hurry to get a product to market, to improve efficiency or productivity, or cut production costs. However, in the seventies, we saw our competitors getting to market faster with a new product or service, producing it more efficiently, improving its quality, and applying it in new ways that simply had not occurred to us (Carnevale et al., 1988). American ingenuity has always been the envy of the world, but the application of our innovations had fallen behind many other industrial countries. Carnevale et al. puts at least part of the blame on the old management style whose traditions are no longer consistent with the realities of modern production and service delivery. The manager in the modern workplace has less direct control over the output of the business and less contact with the more autonomous worker.

Carnevale et al. (1988) credits technology with precipitating this change. New technology has reduced the number of workers needed to produce a particular product or provide service. The automatic teller machine is a commonly cited example of technology providing better customer service while reducing the numbers of tellers needed. Customers have access to banking services 24 hours a day while the bank can cut costs by having less human tellers. In another example, this writer remembers a visit to the United States Steel Gary Works steel plant in the late eighties and being told around 25,000 employees used to work at that plant in the seventies. By 1987 only 7000-8000 workers were employed there and steel production was higher than when 3-4 times that many were employed. With more technology in place and less employees, nonsupervisory workers need skills commonly associated with the management function: self-management skills, interpersonal skills, teamwork skills, and problem-solving skills (Carnevale et al., 1988). Carnevale et al. believe that in the more decentralized and flatter organizations that result from more technology and less people, managers enforce
accountability less by supervising work processes and more by looking at the outcomes of individuals or teams.

In order to respond to the greater customer sensitivity in the new economy, a new work organization is gaining acceptance, the high-performance work system. The inherent flexibility of new technologies requires high-performance organizational structures and processes that are equally flexible (Carnevale & Porro, 1994). These new technologies and processes are matched with more highly skilled and autonomous employees to create an environment that is able to meet the more complex institutional performance goals of the new economy. One of the effects is less dependency on large, centralized management structures. Carnevale and Porro suggest the new performance standards and the technologies that accompany them encourage high-performance work structures that are more flexible and decentralized. Available data suggest that high-performance systems account for a consistent 60% of performance improvements and that as few as 5% and as many as 26% of private workplaces are attempting to install high-performance workplaces (Carnevale & Porro). This movement appears to become more common as successes are well known. A comparison of the traditional and the new workplace, provided by the Office of Technology Assessment (1990), is illustrated in Table 2.
Table 2

*Characteristics of Today’s and Tomorrow’s Workplaces*

<table>
<thead>
<tr>
<th>Traditional Model</th>
<th>High Performance Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strategy</strong></td>
<td></td>
</tr>
<tr>
<td>Mass production</td>
<td>Flexible production</td>
</tr>
<tr>
<td>Long production runs</td>
<td>Customized production</td>
</tr>
<tr>
<td>Centralized control</td>
<td>Decentralized control</td>
</tr>
<tr>
<td><strong>Production</strong></td>
<td></td>
</tr>
<tr>
<td>Fixed automation</td>
<td>Flexible automation</td>
</tr>
<tr>
<td>End-of-line quality control</td>
<td>On-line quality control</td>
</tr>
<tr>
<td>Fragmentation of tasks</td>
<td>Work teams, multi-skilled workers</td>
</tr>
<tr>
<td>Authority vested in supervisor</td>
<td>Authority delegated to worker</td>
</tr>
<tr>
<td><strong>Hiring and Human Resources</strong></td>
<td></td>
</tr>
<tr>
<td>Labor-management confrontation</td>
<td>Labor-management cooperation</td>
</tr>
<tr>
<td>Minimal qualifications accepted</td>
<td>Screening for basic skills abilities</td>
</tr>
<tr>
<td>Workers as a cost</td>
<td>Workforce as an investment</td>
</tr>
<tr>
<td><strong>Job Ladders</strong></td>
<td></td>
</tr>
<tr>
<td>Internal labor market</td>
<td>Limited internal labor market</td>
</tr>
<tr>
<td>Advancement by seniority</td>
<td>Advancement by certified skills</td>
</tr>
<tr>
<td><strong>Training</strong></td>
<td></td>
</tr>
<tr>
<td>Minimal for production workers</td>
<td>Training sessions for everyone</td>
</tr>
<tr>
<td>Specialized for craft workers</td>
<td>Broader skills taught</td>
</tr>
</tbody>
</table>


Table 2 contrasts the differences many see in the changing workplace. Of particular interest here is how the changing workplace affects the skills required by the
workforce. Notice the last two entries under the heading “production”. The movement here is from the simple to the complex; from fragmentation of tasks to work teams of multi-skilled workers, and from manager authority to worker-delegated authority. It is obvious that the employees in the new workplace described here will need to function at a higher level than with the traditional model. Many of the high-skilled workers will come from retraining of existing employees (Carnevale & Carnevale, 1994) while entry-level workers will be expected to have greater skill levels when they apply (“Money Talks”, 1996). It should be pointed out that in 1990 over 70% of the year 2000 workforce were currently employed. Of the remainder, 7% immigrated to this country, leaving only about 22% of the 2000 workforce coming from entry-level workers (Perspectives on Education in America, 1993). Another point evident from Table 2 is a change in management attitude. The new model requires a level of cooperation not present in most companies. Additionally, the new workplace requires frequent investment in training and/or education of employees rather than training just for management and the most highly-skilled workers.

Besides evaluating the worker outcomes, there are other characteristics of the new-management style and the new workplace. In this new workplace, managers assign rewards less on seniority and more on employee know how and performance. A Wisconsin paper manufacturer pays employees additional money when they become proficient at a new job in the team, not for number of years worked (See Appendix A). New managers will also have to demonstrate leadership. One of the attributes of a competitive company is getting new products into production or providing new services quickly. This requires managers to lead non-supervisory employees to participate in the design of production and service delivery systems (Carnevale et al., 1988).

One of the most difficult tasks in the new workplace for some managers is to listen to the workers. The two-way movement of information and ideas is crucial for the success of competitive companies. Improvements of product quality, cost reduction, and
in the delivery of service to the customer occur during the production, testing, and use of new products and services. As a result, Carnevale et al. (1988) maintains that managers need the skills and the institutional savvy to embed two kinds of learning systems as close as possible to the point of production or service delivery. He suggests managers need to be able to teach employees the skills required in their new expanded roles, and to learn from those who make the product, deliver the service, or interact with the customer. The “learn from” idea is a difficult change for those managers who functioned in the older Taylor model where the manager had all the knowledge and the worker just followed orders. This writer has heard of horror stories in industry where a manager made a mistake, gave the production worker an erroneous order the worker knew was wrong, but the employee went ahead and produced the mistake, costing thousands or even millions of dollars. When workers feel management will listen, the employees will make beneficial suggestions. A listening management is required in the new workplace and is part of the new management model.

There is no disagreement that much change has occurred as our domestic markets respond to the global economy. We have seen American companies, as they lost market share to foreign firms, respond by adopting many of the same management and process techniques that make foreign companies successful. Massive use of technology has helped companies return to high level of competitiveness, but have reduced the number of low skill positions. These great changes, however, have caused greater expectations for workers, at least with some companies. Many employers want workers who can function at a higher level, who can use the new technology and be an integral part of a team in the new workplace (Davis & Miller, 1996). Here the link between skilled workers and education is made. Employers frequently criticize the schools for failing to provide a fundamentally skilled entry-level employee for this new economy (Clark, 1988; Gordon, 1990; Jones, 1996; Joyce & Voytek, 1996; Townley, 1989; Woodhead, 1996). The literature seems to indicate that many authors and researchers feel all employees need to
have better skills to fit with the new economy and new workplace. Carnevale (2001) states that “education has become the key ingredient in the 21st Century recipe for growing the economic pie” (p. 33). We will find that many employers are stating that they have a difficult time finding employees who have the skills necessary to function well in their companies. And we will find that many in industry are blaming public education for failing to provide adequate basic education to their students and that these students are ill prepared to enter the job market.

On the other hand, there is some evidence to contradict the above points. Some maintain that while many jobs do indeed require, or will require, increased level of skills, not all employees will need these high skills. Present statistics show the greatest job increase to be in the low paying service sector (60% of jobs created between 1983 and 1993), not in high pay, high skill occupations (Bracey, 1996). Yes, some employees need to be able to think critically, but some question the need for great numbers of employees with advanced skills.

2.5 Skills Employers Say They Need

There is no shortage of studies and surveys claiming to report what worker-skills employers say they need. In the last ten or fifteen years there have been many, many attempts to discern what employees need to know in response to vocal critics from industry who claim a skills shortage exists. The focus of this study is critical-thinking (CT) skills needed on the job, but it is important for the general understanding of the reader to consider CT in the broader context of its role as one of the frequently mentioned needed skills. Kearns and Doyle (1988) state the employers need workers who are broadly and liberally educated. The modern employee has to be better educated, able to think, solve problems, to make informed decisions, and choose the correct course of action (Kearns & Doyle). Here Kearns and Doyle speak of specific attributes of a critical-
thinking person and they obviously place great importance on this skill in particular. Global competition in price, on time processing of financial transactions, and improved quality necessitate that the employees be highly skilled and trained (Baloun, 1995; Clinton, 1987). As companies reorganize and seek to hire this highly-skilled and trained employee, they often claim to find it difficult. Employers are seeking broader and greater skill levels from job hunters who are often unaccustomed to extensive competition and greater skill level demands (Magnum, 1996). What are these skills employers want in their employees and say they are so difficult to find?

Two nationwide studies are frequently cited when addressing the question of workplace skills. The two studies, The Secretaries Commission on Achieving Necessary Skills (SCANS) and a study by the American Society for Training and Development (ASTD) suggest that a serious skills gap exists between workers’ abilities and the expectations of employers. The first, the SCANS Report, has apparently been so influential as to give the School-To-Work movement much of its impetus (Pipho, 1996). The Ohio School-To-Work program cites the global economy and advancing technology as creating a demand for skilled workers (Ohio Department of Education, 1995), but many Ohio youth are ill-prepared for work when they leave high school (Ohio Department of Education and Ohio Business Roundtable, 1998). The conclusion by the ASTD is that employers want a new kind of worker with a broad set of workplace skills - or at least a strong foundation of basics that will facilitate learning on the job (Carnevale et al., 1988). Both the SCANS report and ASTD study have an impressive list of corporate and government sponsors and have garnered a great deal of support.

2.6 ASTD Report

The American Society for Training and Development is a large, non-profit, professional organization representing over 50,000 managers, administrators, educators,
and researchers. The two year project was sponsored by the Employment and Training Administration of the United States Department of Labor and published in 1988 and titled *Workplace Basics: The Skills Employers Want*. The research methodology used by Carnevale et al. (1988) began with a literature search of the skills most mentioned in the media as needed by employers. They interviewed employers and found that industry needs went beyond the basic skills most often cited such as computation, reading, and writing. Carnevale built a network of more than 400 experts who received preliminary findings and were encouraged to give feedback. However, the authors state no research plan nor offer any quantitative data.

Carnevale et al. (1988) argue that the more educated and trained half of the American workforce competes well with counterparts in foreign countries, but the less well educated, the blue collar or production workers, compare less well. He cites the education process in Germany, which invests more heavily in production workers, as a better model to emulate. He believes a lack of attention to the ‘lower half’ of the workforce has resulted in the ‘skills gap’ and this will continue to result in a competitive disadvantage and lowered corporate earnings (Carnevale et al.).

The ASTD report on what skills employers want is important enough to warrant a detailed examination. Carnevale et al. (1988) place great emphasis on the importance of workers acquiring the “basic skills”. These basic skills have been expanded from earlier ideas on what was considered basic. Previously only three skills were considered basic and these are computation, reading, and writing (Carnevale et al.). Berlin and Sum (1988) examined a population of individuals with low basic skills and they discovered that 68% of those arrested, 85% of unwed mothers, 79% of welfare recipients, 85% of
dropouts, and 72% of the unemployed possessed low basic skills. The correlation between low skill levels and the less than desirable life situations dramatically underscores the importance of the lack of attainment of basic skills (Carnevale et al.). However, one might argue that low basic skills are just another characteristic of the segment of the population that exhibits the characteristics cited by Berlin and Sum.

The ASTD study concludes that there are seven main skills that business maintains are important for employees to have or acquire. These skills include 1) learning to learn; 2) competence: reading, writing, computation; 3) oral and written communication; 4) adaptability: creative thinking and problem solving; 5) personal management: self-esteem, work ethic, etc; 6) group effectiveness: able to work with others; and 7) influence: organizational effectiveness and leadership (Carnevale et al., 1988). Because of the importance and influence of *Workplace Basics: The Skills Employers Want* (Carnevale et al.), a closer examination of each of the skill groups is important.

**2.6.1 Learning to Learn**

Learning to learn is identified as the foundation skill because it is the major attribute that allows an individual to keep progressing in life. It is the key that unlocks future success and allows the individual to achieve competency in all other basic workplace skills (Carnevale et al., 1988). Weinstein (1996) calls learning how to learn an essential skill for the 21st century. Business feels that learning capability can affect productivity, innovation, and competitiveness. Important for learning to learn is the identification of each individual’s learning-style, a concept that has been well studied in the field of education. Carnevale et al. emphasizes on-the-job-training that integrates
learning style preference is essential.

The new economy and its inherent changes places importance on the worker who can learn new procedures and new tasks quickly. Learning has become a fact of life in the workplace. Competitive pressures compel employers to shift employees between jobs and responsibilities, putting a premium on the ability to absorb, process, and apply new information quickly and effectively (Carnevale et al., 1988). The amount of new information has grown appreciably in recent years and can only grow even more in the future. The ability of the employees to adapt to changing company needs is a valuable resource and requires individuals who can continue to learn.

2.6.2 Competence: Reading, Writing, and Computation

The basic skills of reading, writing, and computation, often referred to as the 3Rs, have been important for many years. Reports critical of schools in the last fifteen years mention frequently that students are not doing as well as some arbitrary student group of years past and this has spawned “back to basic movements”. However, criticism by business interests over less proficiency in the 3Rs seems to be growing, perhaps because business feels a greater need for employees with such basic skills. Carnevale et al. (1988) suggest that in theory these skills have been essential, but in practice workers have succeeded because of a strong back and willing hands. Under the old management style previously discussed, work was often repetitive with little or no need to read, write, or figure. An illiterate worker could work for years without management, or even co-workers, knowing he or she could not read or write.

In today’s workplace computerized machinery and production processes require a literate worker. The introduction of approaches such as statistical process control (SPC) demand higher mathematical skills and computerized machinery require good reading
skills for efficient use (Carnevale et al., 1988). Proficient writing skills often provide the first step in communicating with customers and coworkers. Most employers today are saying they need a workforce well grounded in these basic skills to be competitive.

Workers spend an average of one and one half to two hours per day reading forms, charts, graphs, manuals, and computer terminals. Writing remains the primary form of communication for transmitting policies, procedures, and concepts. Computation is used daily to conduct inventories, report on production levels, measure machine parts or specifications, and so on (Carnevale et al., 1988, p. 11).

It is worth emphasizing that the need for these basic skills is not new, but, according to some, changes in the workplace require the application of these skills in a widespread manner to an extent never before seen. Carnevale et al. (1988) maintain that deficiencies in these workplace skills create barriers that impair an employer’s ability to meet strategic goals and to be competitive.

2.6.3 Communication: Listening and Oral Communication

Most communication takes place through listening and speaking and workers spend most of their day communicating in some form. The average person spends 8.4% of communication time writing, 13.3% reading, 23% speaking, and 55% listening (Carnevale et al., 1988). Good communication is a crucial ingredient of job success. Carnevale et al. claim that only job knowledge ranks above communications skills as a factor for workplace success. The high-performance workplace that the ASTD report envisions places much greater emphasis on communication skills than the traditional workplace. As change becomes more common in the workplace, employees must be able to adapt and this requires greater levels of communication. Employees who are deficient
in oral and listening skills are handicapped as to their learning and communicating abilities, and their personal and professional development (Carnevale et al.). Poor communication has been cited over the years as the cause of a variety of ills, from the workplace to the family. However, it makes sense when Carnevale et al. suggest that communication is central to the smooth operation of a competitive venture.

2.6.4 Personal Management: Self-Esteem, Goal Setting, Motivation, Personal/Career Development

An employee’s effectiveness on the job is closely related to how the worker feels about him/herself. Much of the problems with work ethic, or lack of, can be traced back to self-esteem issues. A good self-image means an employee takes pride in his or her work and takes responsibility for getting tasks done with quality and in a timely manner. Such an employee can be described in one word, motivated. In the ASTD report, Carnevale et al. (1988) write of the importance of a good self-image. “Today workers are increasingly called upon to make decisions at the point of production or point of sale and to display good interpersonal skills when they work in teams or with customers. The confidence that engenders success in these areas springs from a positive sense of self worth” (Carnevale et al., 1988, p. 13). Ironically, the present near full employment economy requires employers to dip into the segment of the population that bears the effects of such characteristics as poverty and poor decision making. This segment seems to contain more individuals with low self-image and the hiring from this group frustrates employer goals for reaching the high-performance workplace. In addition, the job loss and instability caused by downsizing and mergers contribute to the eroding of self-esteem.

The motivated employee with good self-esteem is so important that employers are encouraged to train their existing staff. “For an employer to succeed in the marketplace,
employees must be motivated: they must possess the ability to set and meet reasonable goals...and workplace training can enhance the employee’s self-esteem” (Carnevale et al., 1988, p. 13). The ASTD report gives the following suggestions to improve self-image (Carnevale et al.):

Key elements of self-esteem training include assisting employees to recognize their current skills; be aware of their impact on others; understand their emotional set points and abilities to cope with stress, change, criticism, and so on; and deal with their own limits by recognizing the need for and seeking new information to apply to problems and construct solutions (p. 13).

Employers would, of course, prefer employees who had a good self-image when hired although probably few look for this characteristic in the applicant. Rather they look for the fruits of the person with a high self-image: pride in work, ability to set and achieve goals, and other signs of the motivated employee.

2.6.5 Group Effectiveness: Interpersonal Skills, Negotiation and Teamwork

It has been mentioned previously that the new economy and the new workplace requires a more collaborative environment than has existed in the past. There has been a great increase in the use of teams in the workplace. The team approach has been linked conclusively to higher productivity and product quality, as well as to increased quality of work life (Carnevale et al., 1988). In order for a group of workers to function well as a team, each must possess expertise in interpersonal skills, negotiation, and teamwork.

Interpersonal skills include many facets. An employee should have the ability to discern and practice appropriate behavior and be able to cope with difficult people whose behavior may not be appropriate. Interpersonal skills also include the ability to absorb
stress, deal with ambiguity, listen, inspire confidence in others, structure social interaction, share responsibility, and interact easily with others (Carnevale et al., 1988).

Conflict is unavoidable in the workplace. It is important for employees to be able to resolve differing positions and solve problems as they arise. Unresolved conflict lessens productivity and results in an undesirable workplace. Good negotiating skills involve separating people from the problem, focusing on issues not positions, inventing options for mutual gain, and insisting on the use of objective criteria (Carnevale et al., 1988). Good negotiation also requires an individual with well-honed interpersonal skills.

Successful teamwork requires expertise in both negotiation and interpersonal skills. By definition, teamwork results from the pooling of the talents of individuals to accomplish tasks and meet goals. The ASTD report describes quality teamwork in the following manner (Carnevale et al., 1988):

> Quality teamwork results when team members know how to recognize and cope with various and unique personalities and when each has a sense of the cultures and approaches that the other team members represent. Team members also need an understanding of group dynamics, which evolve and change as the team approaches its goal. Lastly, team members must be aware of the technical skills that fellow team members have and how these skills might be applied (p. 15).

This call for teamwork in all or most aspects of a workplace differs greatly from the past and is a vital characteristic of the new workplace. All three, interpersonal skills, negotiation, and teamwork, are a vital part of the adaptability and flexibility required for competitiveness.
2.6.6 **Influence: Organizational Effectiveness and Leadership**

The idea of leadership as a necessary skill is a more abstract idea and not easy to define. Each organization has its own dynamic character and skilled employees recognize this fact and know how to adjust. The ASTD report describes this attribute of influence in the following manner (Carnevale et al., 1988):

To be effective in an organization, employees need a sense of the workings of an organization and how their actions affect organizational and strategic objectives. Skilled in scoping out the forces and factors that interfere with the employer’s ability to accomplish its tasks, the worker can be a master problem solver, an innovator, and team builder (p. 15).

The ASTD maintains that organizational effectiveness and leadership skills are basic for success in the new workplace. Workers with these skills can shape a work environment that allows for greater productivity and greater employer competitiveness.

2.6.7 **Adaptability: Creative Thinking and Problem Solving**

The last of the seven skill groups listed in the ASTD report is the one in which this study is most concerned; creative thinking and problem solving. As the reader will find in a succeeding section, creative thinking is closely related to critical thinking and problem solving is a skill often included in the context of critical thinking. Carnevale et al. (1988) include both under the general heading of adaptability. All companies face obstacles in the design and production/delivery of goods and services. How well an organization can create solutions to problems of design and production can determine the success or failure of the business. These pressures put creative thinking and problem
solving at a premium - at all levels of an organization (Carnevale et al.). The ASTD report describes problem solving as the following (Carnevale et al.):

Problem solving skills include the ability to recognize and define problems, and track and evaluate results. Cognitive skills, group interaction skills, and problem processing skills are all crucial to successful problem solving. Training programs in problem solving simulate real problems and are keyed to the organization’s goals (p. 12).

Creative thinking is a closely related term. Often the two are combined in phrases such as creative problem solving indicating the close relationship. Carnevale et al. (1988) suggest that good problem solving comes from the creative mind.

New approaches to problem solving, organizational design, or product development all spring from the individual capacity for creative thinking. In the workplace, creative thinking is generally manifested as creative problem solving or creative innovation. Often a group activity, creative problem solving is characterized by effective teamwork, the examination of a problem in new ways, and the invention of new solutions to existing problems. Either an individual or group activity, creative innovation refers to the development of new activities that expand markets, and improve such elements as productivity (p. 12).

Both creative thinking and problem solving are closely related to critical thinking (CT). Many consider problem solving to be within the context of CT and creative thinking is thought to share some of the realm of CT. This idea will be discussed in detail in the section of this study devoted to defining critical thinking.
In summarizing the ASTD report, it is obvious that the employers surveyed place greater emphasis on higher-level employee skills than has been required in the past. Certainly, there remains the need for basic skills, such as the three Rs, but the ASTD report was one of the very first to cite a need for higher order skills. Claiming that all employees, not just management, need to be proficient in negotiation, teamwork, communication, leadership, problem solving, and creative thinking is a revolutionary idea. This is what makes the ASTD report noteworthy. The critical-thinking aspect of the Report is what is important to this study and the reader will find that the ASTD report is not unique in its inclusion of CT.

2.7 SCANS Report

The Secretary of Labor’s Commission on Achieving Necessary Skills (SCANS) completed two important and widely cited reports. The first, *What Work Requires of Schools*, (Department of Labor, 1991) was published in June, 1991 and the second, *Learning a Living: a Blueprint for High Performance* (Department of Labor, 1992), was introduced to the public in April, 1992.

The Commission was made up of a variety of leaders from management and labor, from manufacturers and service industry, and from both higher education and K-12 educators. Obviously, the make-up of the commission was designed to include representatives from all whom have stakes in workforce skills and education. The then Secretary of Labor, Lynn Martin, did not want a report that would only gather dust, but rather “an action plan for schools and workplaces” (Department of Labor, 1992, p. ix).

The mission of SCANS was to determine the skills that our young people need to succeed in the world of work. The stated purpose was “to encourage a high-performance
economy characterized by high skill, high wage employment” (Department of Labor, 1992, p. xiii). The Report acknowledged that although acquiring the skills to function well in employment is very important, there is more to life than earning a living. The Commission believes “a solid education is its own reward” (Department of Labor, 1991, p. xiii) and does not believe high schools should be turned into trade schools. However, the SCANS Report identifies skill areas that the authors believe should be acquired by all students as a part of their education. These skill areas have been identified as consisting of three foundation skills and five workplace competencies.

The workplace know-how identified by SCANS is made up of five competencies and a three part foundation of skills and personal qualities that are needed for solid job performance. These are listed in Tables 3 and 4 (Department of Labor, 1991).

Table 3

### Workplace competencies: Effective workers can productively use

<table>
<thead>
<tr>
<th>Resources</th>
<th>They know how to allocate time, money, materials, space, and staff.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interpersonal Skills</strong></td>
<td>They can work on teams, teach others, serve customers, lead, negotiate, and work well with people from culturally diverse backgrounds.</td>
</tr>
<tr>
<td><strong>Information</strong></td>
<td>They can acquire and evaluate data, organize and maintain files, interpret and communicate, and use computers to process information.</td>
</tr>
<tr>
<td><strong>Systems</strong></td>
<td>They can understand social, organizational, and technological systems; they can monitor and correct performance; and they can design or improve systems.</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>They can select equipment and tools, apply technology to specific tasks, and maintain and troubleshoot equipment.</td>
</tr>
</tbody>
</table>
Table 3 (continued)


Table 4

*Foundation skills required for employee success in the new economy*

<table>
<thead>
<tr>
<th>Basic Skills:</th>
<th>Reads, writes, performs arithmetic and mathematical operations, listens and speaks.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Reading-locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules.</td>
</tr>
<tr>
<td>B.</td>
<td>Writing-communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, graphs, and flow charts.</td>
</tr>
<tr>
<td>C.</td>
<td>Arithmetic/mathematics-performs basic computations, and approaches practical problems by choosing appropriately from a variety of mathematical techniques.</td>
</tr>
<tr>
<td>D.</td>
<td>Listening-receives, attends to, interprets, and responds to verbal messages and other cues.</td>
</tr>
<tr>
<td>E.</td>
<td>Speaking-organizes ideas and communicates orally.</td>
</tr>
</tbody>
</table>

**Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn, and reasons.

A. Creative Thinking-generates new ideas.
Table 4 (continued)

B. Decision Making-specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative.

C. Problem Solving-recognizes problems and devises and implements plan of action.

D. Seeing things in the Mind’s Eye-organizes and processes symbols, pictures, graphs, objects, and other information.

E. Knowing How to Learn-uses efficient learning techniques to acquire and apply new knowledge and skills.

F. Reasoning-discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem.

Personal Qualities: Displays responsibility, self esteem, sociability

A. Responsibility- Exerts a high level of effort and perseveres towards goal attainment. Displays high standards of attendance, punctuality, enthusiasm, vitality, and optimism in approaching and completing tasks.

B. Self-esteem- Believes in own self worth and maintains a positive view of self; demonstrates knowledge of own skills and abilities; is aware of impact on others; and knows own emotional capacity and needs and how to address them.

C. Sociability- Demonstrates understanding, friendliness, adaptability,
Table 4 (continued)

empathy, and politeness in new and on-going group settings.
Relates well
to others, responds appropriately as the situation requires, and
takes an interest in what others say and do.

D. Self-management- Assesses own knowledge skills and abilities accurately, sets well defined and realistic personal goals, monitors progress towards goal attainment and motivates self through goal achievement, exhibits self-control, and is a ‘self-starter’.

E. Integrity/honesty- Can be trusted. Recognizes when faced with making a decision or exhibiting a behavior that may break with commonly held personal or societal values; understands the impact of violating these beliefs or values on an organization, self, and others; and chooses an ethical course of action.

_______________________________________________________________________


The SCANS competencies and foundation appear to be general and vague. This is necessary because all five competencies apply to all workers in all industries. The members of the Commission believe these competencies are applicable from the shop floor to the executive suite. In the broadest sense, the competencies represent the attributes today’s high performance employer seeks in tomorrow’s employee (Department of Labor, 1991). These competencies and foundation skills are not found to a high level in our population. In fact, many workers do not have what the SCANS Report describes.
SCANS estimates that less than half of all young adults have achieved these reading and writing minimums; even fewer can handle the mathematics; and schools today only indirectly address listening and speaking skills (Department of Labor, 1991). This conclusion, that a skills gap exists, is consistent with other job skill surveys of recent years. But once again, they are referring to jobs applicable to the high-performance workplace; those requiring higher skill levels and offering a higher wage. In fact, the Commission implores organizations to adopt the high-performance work style if they expect to compete with foreign companies.

Employers must orient their business practices to hiring and developing this know-how in employees. If you do not develop a world class workforce, your business will inevitably be at risk. If, for example, only 60% of your employees have these skills, and 90% of Japanese and German workers possess them, you are wasting much more on rework, poor quality, and late deliveries than are your competitors (Department of Labor, 1991, p. viii).

The Commission, it should be pointed out, makes some assumptions that may, or may not, be correct. Whether 90% of German or Japanese workers have the skills similar to the five competencies is questionable. Also it is erroneous to suggest that all businesses are competing with foreign firms. And it is not at all certain that the traditional workplaces in many profitable companies is wrought with rework, poor quality, and late deliveries. Still, the idea of the high skill/high wage earner has merit.

The high skill, high wage job category is the focus of the Commission. Their premise is that if workers have the above competencies and skills, the employee will enjoy a higher wage and a higher standard of living. When the Commission compared
the know-how in 23 high wage jobs with the requirements of 23 low wage jobs, the conclusion was inescapable: workers with more know-how commanded a wage that was 58% or $11,200 a year higher (Department of Labor, 1992). From the employers’ point of view, such skilled workers will be more productive and valuable and are worth the higher wage.

As mentioned previously, the five competencies and three foundation skills apply to all workers in all businesses. Because they are listed in such a general manner, it may be difficult to visualize how these competencies and skills apply to a specific job or business. The SCANS Report gives several examples of how a highly skilled employee might function in a high performance workplace. One of these examples is provided here to assist the reader in understanding the application of the SCANS competencies and foundations. This example, retail trade, was chosen because the retail segment is often the domain of low skill/low wage workers.

Mickey is a salesperson at a computer store on Main Street in a small northeastern city. The store carries a basic line of computers and printers from five different manufacturers, about 15 pieces of equipment in all, varying in size, price, and capabilities. The store also carries a wide range of software, from word processing to database management programs, as well as paper, diskettes, add-on peripherals such as modems, and miscellaneous supplies.

This week the computer company has a sale on laptop computers. Moreover, each member of the sales force who sells 10 or more laptops will receive one free for his or her own use. Mickey goes to the database he maintains on his computer to search his customers’ records for promising purchasers. He
first lists the owners of laptops from the same manufacturer, then the owners of other laptops, and begins placing calls.

At this point, a customer walks into the store. The customer owns a seven-person real estate company. She complains that her salespeople travel so much throughout the region that they cannot stay on top of mortgage rates from different banks or new listings throughout the state. As a result, they are losing sales. Mickey responds, “You have come to the right place. Portable computers—laptops—can solve this problem for you. And, we have a terrific sale on them right now.”

“This model has a built-in modem. If you equip your cars with phones, your employees could download all the information they need just by dialing your office from the car. You also need a desktop computer at your office to answer the phone, but your salespeople could connect with it directly; or, we have a software package called Real Estate Monitor which hooks you up directly to an on-line information service that has up-to-the-minute real estate listings and mortgage rates.”

The customer is intrigued, but worried about its costs. Mickey nods, “Even with the sale we are offering, seven or eight computers is a substantial investment for a small firm. But let me ask you this. You tell me you are losing two or more sales a week because your sales force can’t stay on top of listings and mortgage rates. If this system helps you recoup just one of those sales a week, isn’t it true that it will pay for itself in a month or two?”

“That may be about right,” responds the customer. “My name is Joan
Lewis. Let’s sit down and talk about just how much this is going to cost me.” (Department of Labor, 1991, p. 9).

The above example illustrates application of each of the five SCANS competencies. Salesperson Mickey made effective use of one competency, resources, by having a database of all customers and using computer skills to list products by manufacturer. When a customer enters, Mickey illustrates the interpersonal competency by working with the customer to identify needs. He exercised leadership when he communicated how his store’s products would be an asset to the customer’s real estate business. He handled information well, a third competency. Mickey used his computer to process information and he was able to evaluate this information to the benefit of the customer. When the customer expressed reservations over the cost of Mickey’s recommendations, Mickey exhibited expertise in a fourth SCANS competency, systems. He was able to see the interrelationship between the real estate salespeople’s time and commissions from sales and how his recommendations to the customer would pay for themselves in a couple of months time. Finally, he demonstrated skill in the fifth competency, technology, by selecting the proper technology for the customer and demonstrating how this technology would benefit the customer’s business.

In addition to the above example in retail trade, the SCANS Report lists similar examples for manufacturing, health services, accommodations and food services, and office services. Each of these other examples demonstrated a similar use of the five SCANS competencies. Because of the universal applicability of the competencies, it is important to understand how they might be applied in a specific job situation. This is why one example was included in this study. The benefit of these scenarios is that they begin to do justice to the rich complexity (the problems, demands, rewards, and satisfactions) of high performance work (Department of Labor, 1991). All the work scenarios illustrate that reading, writing, and basic arithmetic are not sufficient in the
high-performance workplace. These skills must be integrated with other kinds of competencies to be fully operational (Department of Labor, 1991). Although the scenarios are admitted by the Commission to be “exceptional performances” in the five competencies, they represent what competent people can and should be able to do on the job.

The above example with Mickey, the sales person, presents a highly competent individual able to function in a complex work environment. This is what the Commission wishes to portray. Often customers find the opposite, a salesperson without vision, unable to move out of a very narrow perspective. The end result is that the customer’s needs are not met and he or she goes elsewhere. Although this is just one example in one part of the economy, the benefits to an organization of people like Mickey are obvious. And more than just one type of worker in an organization can benefit from expertise in the SCANS competencies. The competencies are needed “across the board” and this is illustrated in Table 5 (Department of Labor, 1991).

Table 5

*Competencies needed across the board*

Who needs SCANS competencies? Everyone from the entry-level clerk to managers, executives, or partners in professional corporations. Take the high pressure world of a major law firm of how competence is required across the board.

**Receptionists** are expected to demonstrate personable “front desk” skills (meeting clients and identifying their needs) and to manage complex telecommunication systems without difficulty.
Table 5 (continued)

**Secretaries** are routinely called to work with associates and partners with different, often difficult, working styles and to manipulate computer based data, graphics, and information systems on different kinds of equipment.

**Legal Administrators** help select and oversee the installation of state-of-the-art telecommunication and information systems to meet lawyer’s needs and they also insure that all support personnel are trained in these systems.

**Associates** (junior attorneys) having spent three years learning the rudiments of the legal system and its precedents stretching back to common law, are now expected to put that knowledge to work on specialized problems situated in complex modern systems, e.g. corporations, hospitals, contracts, or civil rights law, and to search for precedents supporting the client’s legal position.

**The Managing Partner** is responsible for ensuring that the cogs and gears of the entire firm operate as a harmonious system— that the support system meets the demands the firm places on it; that the accounting and finance systems follow and recover costs; that the backgrounds of the lawyers meshes with the legal specialty of the firm; and that potentially profitable new areas of client interest can be accommodated.

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One important point to consider is that of level of competency achieved. The expertise exhibited by these several examples are what competent, proficient, and experienced people can accomplish. The SCANS Report recognizes, however, as the above table indicates, that not all work requires the same level of competency and that entry workers often lack the experience or maturity that precedes reaching highest competency. The Commission was asked to propose acceptable levels of proficiency; that is, to answer the questions: What is the threshold level for each competency and foundation skill for entry-level work? How much know-how is enough for a typical job ladder (Department of Labor, 1991)?

It is obvious that the simplest and least proficient level is preparatory and the skill level increases going from number one through number five. An individual holding preparatory skills would be suitable only for unskilled work while a specialist would be suitable for jobs requiring special expertise. The Commission believes that students, with proper preparation, should achieve at least a work-ready level on this scale (Department of Labor, 1991). An illustration of the comparison between proficiency level and performance is given in Table 6.

Table 6

*Competencies based on proficiency level*

<table>
<thead>
<tr>
<th>Proficiency Level</th>
<th>Performance Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparatory</td>
<td>Scheduling oneself</td>
</tr>
<tr>
<td>Work-ready</td>
<td>Scheduling small work team</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Scheduling a production line or a substantial construction project</td>
</tr>
<tr>
<td>Advanced</td>
<td>Developing roll-out schedule for a</td>
</tr>
</tbody>
</table>
Many adults have not progressed beyond the work-ready level, some not even beyond the preparatory level. SCANS believes the competencies cannot be learned outside of school. Workplace know-how is something that is not just picked up. It must be taught and it must be learned (Department of Labor, 1991). Perhaps this is shortsighted. They should give more credit to informal training and education and the self-motivation of many individuals who have demonstrated success without formal instruction in workplace skills.

The Commission believes the work-ready status should be the goal of the schools (Department of Labor, 1991). An example of the type of readiness needed in a manufacturing setting is given in Table 7.

Table 7.

*Manufacturing know-how: Level of competence expected for entry on a career ladder*

<table>
<thead>
<tr>
<th>Competence</th>
<th>Example of a Work-ready Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources</td>
<td>Develop a plan to show how the production schedule can be maintained while the staff is trained in a new procedure. Estimate the number of additional employees or overtime</td>
</tr>
<tr>
<td>Category</td>
<td>Activity</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Interpersonal</td>
<td>Join a production team brainstorming to find ways to include two new workers who speak limited English in the plant’s improvement program. The goal is to have all team members, whatever their English skills, make weekly suggestions to improve product quality.</td>
</tr>
<tr>
<td>Information</td>
<td>Analyze statistical control charts to monitor error rate. Develop, with other team members, a way to bring performance in your production line up to that of best practice in competing plants.</td>
</tr>
<tr>
<td>Systems</td>
<td>As part of information analysis above, analyze painting system and suggest how</td>
</tr>
<tr>
<td>Table 7 (continued)</td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td></td>
</tr>
<tr>
<td>improvements can be made to minimize system downtime and improve paint finish.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluate three new paint spray guns from the point of view of costs, health and safety, and speed. Vendors describe performance with charts and written specifications. Call vendor’s representatives to verify claims and seek the names of others using their equipment. Call and interview references before preparing a report on the spray guns and making a presentation to management.</td>
</tr>
</tbody>
</table>


The skills listed in Table 7 seem well beyond what most individuals do on the job and equally beyond what the average high school, or even college students, have done in preparation for work. Yes, certainly employees do the above tasks, but labeling the above as “work-ready” seems overdone. The above skills, and those in other SCANS examples, appear to be more in the intermediate or even advanced category. The SCANS report does not give examples of intermediate, advanced, or specialist skills in any job area. It would be interesting to see what skills would be listed in these higher proficiency levels.

In summary, the SCANS Report is a comprehensive and influential examination
of workforce skills needed for present and future jobs. It focuses on five competencies the Commission suggests are necessary and required by all kinds and types of businesses if these businesses wish to successfully compete in the new global economy. The five competencies arise from three foundation skills. SCANS believes the acquisition of the five competencies are necessary for even entry level employees and schools should be teaching the competencies as part of their curriculum. The Report assumes that all employers see the need to transform their organizations into world-class, high-performance workplaces requiring highly skilled employees. Companies who do not embrace this idea are implied to be doomed to failure. SCANS maintains that all students can learn these advanced skills despite the fact that many students cannot pass a ninth-grade proficiency test and some cannot pass a twelfth-grade test. This indicates that the foundation skills are not present in many students and therefore the five competencies based on the foundations also must be absent, at least to some degree. Are the SCANS competencies for all workers realistic and attainable? That is the big question in this writer’s mind.

2.8 Knowledge and Know-how: Meeting Ohio’s Skill Gap Challenge

The Ohio Department of Education and the Ohio Business Roundtable, in cooperation with American College Testing (ACT), Inc., joined forces in 1996 for the purpose of determining the work readiness of a representative sample of Ohio high school seniors. This was called the Ohio Skill Gap Initiative. The jobs for which the readiness of the seniors were to be tested were high skill, entry level positions, ones that exist now and in the future. The Ohio Skill Gap Initiative’s goal was to answer two fundamental questions (Ohio Department of Education & Ohio Business Roundtable, 1998):

1. What foundation skills and level skills do entry level employees need to
succeed in today’s high performance workplace?

2. Do the students graduating from Ohio’s public schools possess the foundational skills which will permit them to acquire the knowledge and know-how needed for successful entry into-and advancement through the present and future workplace (p. 2)?

When this organization was formed and called itself the Ohio Skills Gap Initiative (OSGI) and attempted to answer question two above, can there be any other conclusion than that a skills gap exists? Nevertheless, this is a comprehensive, statewide study of 14,474 students from 119 Ohio public schools and worthy of close examination and consideration in this study.

Answering the first question was quite simple; the OSGI simply selected four skill areas for study. The four areas are 1) applied mathematics, 2) reading for information, 3) applied technology, and 4) locating information (Ohio Department of Education & Ohio Business Roundtable, 1998). A general description of each area follows in Table 8.

<table>
<thead>
<tr>
<th>Skill areas for entry level positions</th>
</tr>
</thead>
</table>

**Applied Mathematics**: Skill in applying mathematical reasoning to a variety of work related problems.

**Reading for Information**: Skill in reading and understanding written work related instructions and policies.

**Applied Technology**: Skill in solving problems of a technical nature such as applying principles of mechanics, electricity,
thermodynamics, or fluid dynamics to machines and systems.

**Locating Information:** Skill in interpreting and using workplace graphics, such as diagrams, floor plans, tables, graphs, charts, and instrument gauges.

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**Note.** From *Knowledge and Know-how, Meeting Ohio’s Skill Gap Challenge* (p. 5), by the Ohio Department of Education, 1998, Columbus, OH.

The OSGI does not explain their reasoning for selecting these four, but feel they represent a common reference point.

This description is not based on the entire range of skilled jobs in each career area, and it does not capture all the skills a student would need for job success. It does make it possible, however, to set a common reference point for measuring some significant areas of performance and to establish a common language for discussing career paths, skills, and skill levels (Ohio Department of Education & Ohio Business Roundtable, 1998, p. 5).

The entire process of the analysis of critical work skills was completed using a four-step process designed by ACT, Inc. and these steps are presented in Table 9.
Table 9

*Skill Selection Process*

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>Selecting four skill areas to be assessed</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>Selecting job profiles from ACT’s database that reflect Ohio’s present and future labor market needs</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>Grouping job profiles into job clusters</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>Determining required skill levels</td>
</tr>
</tbody>
</table>

*Note.* From *Knowledge and Know-how, Meeting Ohio’s Skill Gap Challenge* (p. 5), by Ohio Department of Education, 1998, Columbus, OH.

The OSGI determined that there are five job clusters and seven skill levels. Number 1 for the lowest level of skill and 7 for the highest identifies the seven skill levels. Only 3 through 7 were considered for this study because OSGI felt levels 1-2 were too low skilled to qualify for the higher skilled positions they were examining (Ohio Department of Education & Ohio Business Roundtable, 1998). A comparison of skill levels is given in Table 10.
Table 10

*Comparison of Job Skills of Lowest and Highest Skill Levels (Level 3 and Level 7)*

<table>
<thead>
<tr>
<th></th>
<th>Lowest Skills-Level 3</th>
<th>Highest Skills-Level 7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Applied Mathematics</strong></td>
<td>Deal with simple mathematical operations such as calculating change or adding together the price of several products</td>
<td>Convert between measurement systems involving fractions, mixed decimals, and percentages. Calculate areas or volumes of shapes. Set up and manipulate complex ratios and proportions.</td>
</tr>
<tr>
<td><strong>Reading for Information</strong></td>
<td>Handle short, simple reading material with elementary vocabulary such as straight-forward memos or instructions</td>
<td>Deal with very detailed such as excerpts from regulatory and legal documents. Apply general to new and somewhat dissimilar situations.</td>
</tr>
<tr>
<td><strong>Applied Technology</strong></td>
<td>Apply elementary physical principles, such as the use of heat to expand and loosen a</td>
<td>Solve more complicated problems, often applying principles that affect certain</td>
</tr>
</tbody>
</table>
### Table 10 (continued)

<table>
<thead>
<tr>
<th>Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>metal nut stuck to a bolt.</td>
<td>properties of a system such as phase change or pressure equilibrium.</td>
</tr>
<tr>
<td>Understand the operation of basic hand tools, simple machine components, and simple systems.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Locating Information</th>
<th>Use simple order forms, bar graphs, tables, flow charts, and floor plans. Find pieces of information in elementary graphics. Fill in missing information in a graphical presentation.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Use computer graphics with a great amount of information. Use graphics to draw conclusions. Apply graphical information to situations.</td>
</tr>
</tbody>
</table>

**Note.** From *Knowledge and Know-how, Meeting Ohio’s Skill Gap Challenge* (p. 8), by the Ohio Department of Education, 1998, Columbus, OH.

Comparing the jobs with the skill levels, the more technical jobs are, as expected, aligned with the higher skill levels. For example, level three, the lowest level, in applied mathematics lists such jobs as laborer, industrial cleaner, and counter supervisor. Level 7 lists occupations such as avionics technician, electrical engineer, and industrial engineer. Similar job-to-skill level associations are found with the other three skill areas. Each occupation selected for the skill gap study requires at least a high school diploma, has a median annual salary of at least $15,000, and is projected to show a growth rate of 10% or more through the year 2005 (Ohio Department of Education & Ohio Business Roundtable, 1998). The authors claim that "in general, the jobs selected do not require
extensive post-secondary education" (Ohio Department of Education & Ohio Business Roundtable, 1998, p. 6). However, this does not seem to be accurate. True, levels 3 and 4 list occupations a high school graduate would be qualified for such as, janitor, machine operator, and shipping order clerk. But once above level 4, most jobs listed require extensive post-secondary education and some even a four-year college degree, such as electrical and industrial engineer.

To answer the second research question, The OSGI tested 14,474 seniors at 119 schools to determine the skill level of Ohio students (Ohio Department of Education & Ohio Business Roundtable, 1998). A stratified cluster sampling method was used to ensure representation from a cross-section of Ohio schools including urban, suburban, and rural schools. Tests were administered using a technique called spiraling. There were separate tests for each of the four areas: applied mathematics, reading for information, applied technology, and locating information. Only seniors were tested and each senior was given only one test. The tests were organized so that the first student in a group was given test A (perhaps Applied Mathematics), the second given test B (Reading for Information), the third given test C (Applied Technology), and the fourth given test D (Locating Information). Starting with the fifth student, the sequence is repeated. The authors claim this method works when all the tests have the same time limit. The results of the tests are given in Table 11.
Table 11

Ohio Assessment Results

<table>
<thead>
<tr>
<th>Level</th>
<th>Applied Mathematics</th>
<th>Reading for Information</th>
<th>Applied Technology</th>
<th>Locating Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>6%</td>
<td>4%</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>6</td>
<td>21</td>
<td>22</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>5</td>
<td>29</td>
<td>32</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
<td>33</td>
<td>12</td>
<td>55</td>
</tr>
<tr>
<td>3</td>
<td>14</td>
<td>5</td>
<td>30</td>
<td>18</td>
</tr>
<tr>
<td>Below 3</td>
<td>5</td>
<td>4</td>
<td>54</td>
<td>8</td>
</tr>
</tbody>
</table>

Note. Percentages represent those achieving minimum performance for that level of the whole sample. From Knowledge and Know-how, Meeting Ohio’s Skill Gap Challenge (p. 11), by the Ohio Department of Education, 1998, Columbus, OH.

For example, Table 11 indicates that only 6% achieved minimum performance at level 7 for applied mathematics. This means that of the 14,474 Ohio students who participated, only 868 were able to perform at the highest skill level in applied mathematics. It also means, by adding the percentages, that 81% performed above level 3 for applied mathematics.

By examining this table, it is evident that most seniors have an acceptable level of work ready skills with the exception of Applied Technology. The authors foresaw student difficulty in this area and considered omitting this category because fewer students take courses aimed at applied technology. Table 11 shows few students able to demonstrate expertise at the higher skill levels 6 and 7, but the majority appears to have some level of skills needed by employers. Only a very few demonstrated a lack of employable skills, 8% or less in three of the four categories.
The OSGI report examines each of the four skill areas by matching occupation groups with skill levels and comparing test scores with these occupation groups. This information is given in tables 12 through 15 (Ohio Department of Education & Ohio Business Roundtable, 1998).

Table 12

*Requirements for the Applied Mathematics Skill in Specific Occupations*

<table>
<thead>
<tr>
<th>Level</th>
<th>Occupation</th>
<th>Percentage achieving skill level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 7</td>
<td>Avionics Technician</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>Department Manager</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electrical Engineer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial Engineer</td>
<td></td>
</tr>
<tr>
<td>Level 6</td>
<td>Instrument Mechanic</td>
<td>27%</td>
</tr>
<tr>
<td></td>
<td>Nurse</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mechanical Drafter</td>
<td></td>
</tr>
<tr>
<td>Level 5</td>
<td>Administrative Assistant</td>
<td>56%</td>
</tr>
<tr>
<td></td>
<td>Computer Operator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diesel Mechanic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maintenance Mechanic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Numerical Control Machine Operator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Secretary</td>
<td></td>
</tr>
</tbody>
</table>
Table 12 (continued)

<table>
<thead>
<tr>
<th>Level 4</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Service Representative</td>
<td>81%</td>
<td></td>
</tr>
<tr>
<td>Janitor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machine Operator I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastics Fabricator</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level 3</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Counter Supervisor</td>
<td>95%</td>
<td></td>
</tr>
<tr>
<td>Industrial Truck Operator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial Cleaner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laborer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shipping Order Clerk</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Percentages represent those scoring at or above each level. From *Knowledge and Know-how; Meeting Ohio’s Skill Gap Challenge* (p. 12), by the Ohio Department of Education, 1998, Columbus, OH.

The above table represents a student's ability to apply mathematical reasoning and problem solving techniques in work-related problems specific to those occupations listed. The OSGI states that the theoretical aspects of algebra and geometry, such as the manipulation of formulas or developing proofs, are not required. Therefore, those students who have taken algebra or geometry may have found it helpful in answering test questions, but taking these courses were not required for answering questions correctly.
<table>
<thead>
<tr>
<th>Level</th>
<th>Occupation</th>
<th>Percentage achieving skill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 7</td>
<td>Avionics Technician</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>Electrical Engineer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lawyer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OSHA Inspector</td>
<td></td>
</tr>
<tr>
<td>Level 6</td>
<td>Administrative Assistant</td>
<td>26%</td>
</tr>
<tr>
<td></td>
<td>Department Manager</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nurse</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Instrument Mechanic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial Engineer</td>
<td></td>
</tr>
<tr>
<td>Level 5</td>
<td>Computer Operator</td>
<td>58%</td>
</tr>
<tr>
<td></td>
<td>Diesel Mechanic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maintenance Mechanic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mechanical Drafter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Secretary</td>
<td></td>
</tr>
</tbody>
</table>
Table 13 (continued)

<table>
<thead>
<tr>
<th>Level 4</th>
<th>Industrial Cleaner</th>
<th>91%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Industrial Truck Operator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Janitor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Machine Operator I</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plastics Fabricator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Laborer</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level 3</th>
<th>Customer Supervisor</th>
<th>96%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shipping Order Clerk</td>
<td></td>
</tr>
</tbody>
</table>

**Note.** Percentages represent those scoring at or above each level. From *Knowledge and Know-how, Meeting Ohio’s Skill Gap Challenge* (p. 13), by the Ohio Department of Education, 1998, Columbus, OH.

Table 13 presents reading for information data that involves skill in reading and understanding work-related information. The OSGI describes this skill as ranging from reading short, simple reading material with elementary vocabulary, such as straightforward memos or instructions, to very detailed material, such as excerpts from regulatory and legal documents in which employees must apply general principles to new and somewhat dissimilar situations (Department of Education & Ohio Business Roundtable, 1998).
Table 14

*Requirements for the Applied Technology Skill In Specific Occupations*

<table>
<thead>
<tr>
<th>Level</th>
<th>Occupation</th>
<th>Percentage achieving skill level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 6</td>
<td>Avionics Technician</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Computer Operator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diesel Mechanic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Instrument Mechanic</td>
<td></td>
</tr>
<tr>
<td>Level 5</td>
<td>Electrical Engineer</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>Industrial Engineer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Machinist</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maintenance Mechanic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mechanical Drafter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Numerical Machine Operator</td>
<td></td>
</tr>
<tr>
<td>Level 4</td>
<td>Customer Service Representative</td>
<td>16%</td>
</tr>
<tr>
<td></td>
<td>Department Manager</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial Cleaner</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial Truck Operator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Machine Operator I</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nurse</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plastics Fabricator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Secretary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shipping Order Clerk</td>
<td></td>
</tr>
</tbody>
</table>
Table 14 (continued)

Level 3  Administrative Assistant  46%
        Counter Supervisor
        Janitor
        Laborer

Note. Percentages represent those scoring at or above each level. From *Knowledge and Know-how, Meeting Ohio’s Skill Gap Challenge* (p. 14), by the Ohio Department of Education, 1998, Columbus, OH.

The Applied Technology test measured skill at applying basic principles of mechanics, electricity, fluid dynamics, and thermodynamics to solve technical problems. The OSGI states that the emphasis is identifying relevant aspects of problems, analyzing and ordering those aspects, and applying existing materials or methods to new situations (Ohio Department of Education & Ohio Business Roundtable, 1998). This is the skill area of the four that demonstrates the least level of student expertise. The OSGI anticipated this low performance and stated that the reason is that "most high school seniors have not taken course work that covers this information since their last general science course, often in seventh or eighth grade" (Ohio Department of Education, 1998, p. 14).
Table 15

Requirements for the Locating Information Skill in Specific Occupations

<table>
<thead>
<tr>
<th>Level</th>
<th>Occupation</th>
<th>Percentage achieving skill level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 6</td>
<td>Avionics technician</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Department Manager</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electrical Engineer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial engineer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OSHA Inspector</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mechanical Drafter</td>
<td></td>
</tr>
<tr>
<td>Level 5</td>
<td>Computer Operator</td>
<td>19%</td>
</tr>
<tr>
<td></td>
<td>Customer Service Rep</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diesel Mechanic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Instrument Mechanic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maintenance Mechanic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Numerical Machine Operator</td>
<td></td>
</tr>
<tr>
<td>Level 4</td>
<td>Administrative Assistant</td>
<td>74%</td>
</tr>
<tr>
<td></td>
<td>Counter Supervisor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial Truck Operator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Janitor</td>
<td></td>
</tr>
</tbody>
</table>
Table 15 (continued)

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Operator I</td>
<td>92%</td>
</tr>
<tr>
<td>Nurse</td>
<td></td>
</tr>
<tr>
<td>Secretary</td>
<td></td>
</tr>
<tr>
<td>Shipping Order Clerk</td>
<td></td>
</tr>
<tr>
<td>Level 3 Industrial Cleaner</td>
<td></td>
</tr>
<tr>
<td>Laborer</td>
<td></td>
</tr>
<tr>
<td>Plastics Fabricator</td>
<td></td>
</tr>
</tbody>
</table>

Note. Percentages represent those scoring at or above each level for skills required to do listed occupations. From Knowledge and Know-how, Meeting Ohio’s Skill Gap Challenge (p. 15), by the Ohio Department of Education, 1998, Columbus, OH.

The locating information skill involves using information presented in workplace graphics such as diagrams, floor plans, tables, forms, graphs, charts, and instrument gauges (Ohio Department of Education & Ohio Business Roundtable, 1998). At the higher levels, students were asked to find information on multiple graphs, charts, etc. No mathematics was required to answer this section.

The OSGI used the data in the previous four tables to conclude that most Ohio high school seniors are not prepared for work. The authors refer to student performance described in terms of the percentage of jobs for which the individual would qualify, stated as a percentage, usually 50% or 80% (Ohio Department of Education & Ohio Business Roundtable, 1998). The OSGI chose to present data showing what percentage of Ohio high schools seniors would meet or exceed the skill requirements in each area for 80% of
the profiled jobs in each of the five job clusters: business contacts/operations, technical, arts, social service, and science. Profiled jobs are those used as examples in Tables 12 thru 15. This is presented in Table 16.

Table 16

*Proportion of Ohio Students Who Meet or Exceed the Skill Requirements for 80% of the Profiled Jobs*

<table>
<thead>
<tr>
<th>Business Contacts/Operations</th>
<th>Applied Mathematics</th>
<th>Reading for Information</th>
<th>Applied Technology</th>
<th>Locating Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>82</td>
<td>58</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>Arts</td>
<td>56</td>
<td>26</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>Social Service</td>
<td>27</td>
<td>26</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Science</td>
<td>27</td>
<td>6</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>

Note. From *Knowledge and Know-how, Meeting Ohio’s Skill Gap Challenge* (p. 17), by the Ohio Department of Education, 1998, Columbus, OH.

The OSGI drew one conclusion that was published in a number of Ohio newspapers. The OSGI points out that employers do not hire based on just one or two skills, but rather hire employees who exhibit a broad base of skills. The OSGI had the following to say about generalizing their data on individual skills to multiple skill assessment with the general population of high school seniors (Ohio Department of Education & Ohio Business Roundtable, 1998).
The method by which Ohio student information was collected, with each student assessed in only one skill area, does not allow direct calculation of the effect of requiring students to meet the profile in multiple skill areas. However, ACT's database of assessment information can be used to provide an estimate of how Ohio students meet employers' multiple skill requirements. Given the information available, about one high school senior in every 14 (7%) could meet the average profile across all four skill areas. Because, as expected, Ohio seniors did not perform well on the Applied Technology assessment, this estimation was made without consideration of that skill area. If only the other three skill areas are considered, the proportion of Ohio's seniors meeting employers' multiple skill requirements doubles to about 14 percent. What this means is that 14 percent of the seniors could meet the profile for Applied Mathematics, Reading for Information, and Locating Information that was established in this study (p. 18).

This was the major conclusion of the OSGI study. The 14 percent figure of employable seniors obviously seems quite low, even alarming to some and, again, this was the fact given to the public. This study is biased and flawed. The first of two research questions was to determine if a skills gap exists in Ohio. When the organization attempting to answer this question calls itself the Ohio Skills Gap Initiative, it becomes obvious what the answer will be. This bias taints the entire study.

The flawed nature of the study is revealed in Tables 12 through 15. For example, Table 12 illustrates that 95% of Ohio high school seniors have the applied mathematics skill to function at level 3. Table 12 also indicates only 6% of seniors have the applied mathematics skills required of occupations listed for Level 7. What occupations are
given as examples of Level 7? Avionics technician, department manager, electrical engineer, and industrial engineer are the listed occupations. These are not entry-level positions for a graduating high school student and it is odd that the applied mathematics skill of a senior is compared to that of an engineer with a college degree. This comparison of measured skills of high school seniors to the skills of older and more mature individuals in occupations that require additional training and education, often a two or four year degree, is the great flaw of this investigation. This flaw is illustrated in each of the four skill areas.

For those entry level occupations for which a graduating senior might qualify, such as laborer, shipping order clerk, industrial cleaner, and administrative assistant, the vast majority have the skills according to the Ohio Skills Gap Initiative. In addition to the 95% cited above as skilled for level 3 in applied mathematics, 96% are skilled at level 3 for the Reading for Information skill, 92% skilled at level 3 for the Locating Information, and 46% skilled at level three for the Applied Technology. These latter three skill areas also compare high school seniors' skills to more mature, trained, and educated individuals in occupations not open to graduating seniors without additional training and education.

This comparison of eighteen year olds' skills in applied mathematics and technology, locating information, and reading information with many occupations requiring additional education and maturation skews the data in favor of a skills gap. Their own data suggests the opposite. For those occupations requiring only a high school diploma, Ohio high school seniors overwhelmingly have the skills.

The three studies, the ASTD Report (Carnevale et al., 1988), the SCANS report (Department of Labor, 1991, 1992), and the OSGI (Ohio Department of Education & Ohio Business Roundtable, 1998) present a bleak, but hopeful, picture of what employers state they require in their employees. The differences and similarities support both arguments that 1) companies cannot agree on what pre-employment skills are important or 2) there is a general consensus on what is needed. The 1998 publication date of the
OSGI indicates that this issue is far from settled. All reports make the assumption that all students can attain these advanced skills, but this may not be possible. However, other evidence suggests that employers don’t need massive numbers of workers with these higher level skills.

2.9 Too Many High Skill Workers?

Despite the rhetoric about severe shortages in skilled workers, there is widespread evidence that corporations are reducing the numbers of employees, many of these are highly skilled. For example, Louis Gerstner, CEO of IBM, fired 90,000 employees in 1993, about 1/3 of IBM’s 270,000 workers. This is in addition to 180,000 employees let go before Gerstner arrived (“Big Blue’s White Elephant Sale”, 1994). This is the same Louis Gerstner who is principal author of a book that criticizes American educators for not increasing America’s supply of workers with high-tech skills and problem-solving ability (Gerstner, Semerad, Doyle, & Johnston, 1994). This is not an isolated case. Xerox, AT&T, Bank of America, United Technologies, General Motors, and other Fortune 500 companies laid off more than 583,000 high skill workers in 1993 (“Downsizing Continues”, 1993). In 1994 the reductions continued; GM dropped 74,000 workers, AT&T fired 83,500, Sears fired 50,000, GTE fired 32,150 (“For a Pink Slip”, 1995). These are some examples of what is and has been a general trend in industry for well over a decade. Certainly some laid off employees are not highly skilled, but many are. In most companies the most highly skilled are the highest paid and the greatest targets for downsizing. What happens to these workers? Where do they go?
It appears that large numbers of fired workers are rehired into low wage service jobs or temporary positions. In 1994 two-thirds of all new jobs created in the U.S. were low wage jobs that carried no benefits (“Strong Employment Gains”, 1994). At least 25% of those employed today are temporary, part-time, or contract workers and the number of Americans working in this manner increased by 2.2 million from 1973 to 1996, reaching a total of 6.2 million (“Use of Contingent Workers”, 1995). These are said to be involuntary part-timers, those that would rather be working full-time. Bracey (1996) found employment growth between 1983 and 1993 was greater for occupations in the top and bottom of the earnings distribution rather than in the middle where high skill jobs are said to reside. These figures stand in direct contradiction to voices in industry complaining about a shortage in high skill workers and criticizing the schools for failing to produce such employees. It seems business needs a lot more menial workers and lots fewer high-skilled types (Boutwell, 1997; Van Horn, 1997). This is not the only contradiction.

There is evidence that many employers do not agree with current rhetoric about skill shortage. Concerning academic skills, an analysis of the Youth Cohort of the National Longitudinal Study indicates that after the first ten years after leaving high school, greater competence in science, language arts, and mathematical reasoning lowers wages and increases unemployment of young men (Bishop, 1992). For young women, verbal and scientific competencies have no effect on wage rates, and a one grade level increase in mathematical reasoning competence raises wage rates by only one half of one percent (Bishop, 1989). In fact, many would be pleased if prospective employees possessed more traditional traits and were not concerned with higher level skills. A
Delphi study of the SCANS foundation skills and competencies found 24 panelists ranking 1) integrity/honesty, 2) reading, 3) serves clients and customers, 4) responsibility, and 5) participates as part of a team as their top five skills (Wilhelm, 1999). These are more traditional traits, not the high level skills mentioned in the SCANS report and ASTD survey. Even teachers do not agree whether or not academic skills are valuable in the workplace (Bauers & Briscoe, 1996). Outstanding employees are those that have good attitudes, get along well with others, and who “fit in” (Holton, 1995). Another study, Perspectives on Education in America (1993), commonly known as the Sandia Report, cites a survey of employers from the National Center on Education and the Economy which indicated little or no skill level problems. It is interesting to note that members of the Bush administration withheld the Sandia Report because it contained statistics in opposition to goals in Bush’s America 2000 (Tanner, 1993). Three conclusions from this report also differ from those suggesting a shortage of high skill employees. First, only 5% of employers feel education and skill requirements are increasing significantly. Secondly, only 15% of employers report difficulty finding skilled workers. Shortages generally occur in chronically underpaid areas. Finally, over 80% of employers express concern over “skills”, but they generally mean a good work ethic and social skills (Perspectives on Education).

This is a quite different picture. Only one in twenty employers even believe skill requirements are increasing significantly and few have problems finding workers that meet their expectations. Eighty percent of employers express concern about “skills”, but not the higher level examples proposed by SCANS and ASTD, but lower skills. In fact, some may argue that these are not really skills at all, but traits.
The Sandia Report cites two independent workforce skill surveys conducted by 1) the Michigan Employability Skills Task force for the Michigan Legislature and 2) the National Center for the Education and the Economy for the Rochester City Schools, Rochester, New York (Perspectives on Education, 1993). According to the Michigan survey, the most important skills were 1) no substance abuse, 2) honesty, integrity, 3) following directions, 4) respect others, and 5) punctuality and attendance (Perspectives on Education, 1993, p. 296). The Rochester study was very similar. It identified the five most important skills as 1) no substance abuse, 2) follow directions, 3) read instructions, 4) follow safety rules, and 5) respect others (Perspective on education, 1993, p. 296).

In 1997 a survey was done for the South Metro Chamber of Commerce (Dayton, Ohio) Business Advisory Council to assess employer skill needs (Cited in Mansfield News Journal, August 28, 1999, p. A1). Four hundred Dayton area employers were surveyed by telephone. People who were responsible for hiring and training employees were asked to rank 13 skills in order of importance. The first five ranked skills in ascending order were 1) honesty, 2) willingness to cooperate, 3) ability/willingness to follow directions, 4) positive attitude, and 5) punctuality. The skills ranked last in order from most valued to least valued were 1) basic math skills, 2) basic writing ability, 3) understanding of business economics, and 4) basic computer skills (p. A1).

What a strikingly different picture this is. The conclusions by the Sandia Report and the Dayton survey about workplace skill needs differ drastically from those presented by SCANS and ASTD yet all are based on employer surveys. There is no differentiation by type or class of worker nor specific job. The higher level skills promoted by the
SCANS and ASTD appear to be more applicable to the more responsible, highly paid positions and the above lists fits a more general description.

Despite the obvious uncertainty about employer needs, state education systems as well as local school districts have made changes in curricula to attempt to produce a more hirable graduate. It is not surprising that no sure recipe for success has emerged in the literature in recent years given the less than solid foundation. Without having a reasonably clear picture of employer needs, it seems foolish to attempt reform. It is absurd to assume that all employers across many industries and management styles have the same employee skill requirements. It is equally absurd for any single employer of any size to state a list of skill levels applicable to all employees when any business contains a quite varied array of tasks which require differing levels and types of expertise. Researchers have discovered also that skill level requirements vary by who in business makes up the list. For example, the CEO will likely provide a list of requirements similar to SCANS and ASTD while the human resources director may cite needs more in line with the Sandia report.

Most high schools have curricula in place that have had only minor changes in one hundred or so years. At the beginning of the twentieth century, high schools were not for everyone. They were designed to educate the top end of the school population, not train for jobs, but truly educate. There is a difference between training and education that seems to be lost on much of our population. So many individuals equate the two ideas. Generally, our schools are in the business of educating youth, not training. A trained person has learned to carry out a specific procedure in a prescribed manner. Automobile technicians are trained. Cosmetologists are trained, as are truck drivers. An educated
person can analyze and synthesize ideas and information. Such a person can evaluate concepts and apply what is learned to new situations. An educated individual can be successful in a wide variety of occupations because an educated person is an adaptable individual. It seems prudent and desirable for schools to continue the emphasis on the education of youth when considering how to respond to the critics from the business world.

What should be the response by educators to the conflicting demands from industry for better prepared youth? If reform is needed, it should be based on a solid foundation of research, which gives a clear direction for movement. Despite the work of very prestigious organizations, such solid foundation does not appear to exist.

The question of employee skill needs and associated school reform is much too large a project for a small study by one individual. It seems prudent to focus on one important skill frequently cited and determine if research into this skill can provide the foundation and direction for reform. One of the skills deemed necessary by many employers is the ability of the employee to think critically on the job (Carnevale, 1992, 1989; Carnevale et al., 1988; Department of Labor, 1991, 1992; Ohio Department of Education & Business Roundtable, 1998). It has been argued that the need for workers adept at critical thinking is increasing and will continue to increase as global industrial competition intensifies. And the ability to think critically has long been recognized as a desirable educational objective and a major goal of instruction (Yoesting & Renner, 1969). It has been suggested that reform of instructional methods and materials is absolutely crucial to better prepare students to think critically.
It is the purpose of this study to attempt to answer several questions relating to employer critical thinking needs and how educators, the science education community in particular, should respond to these needs, if at all? Do all employers need all employees to be adept at critical thinking? If not all, then which areas of employment need critical thinkers? And what percentage of the total do they comprise? Is there a rising skill need by business? How many companies practice the ‘new’ management style, which some claim requires employees able to think critically at a higher level? If the level of proficiency of critical thinking is to be raised by formal instruction, then what should science educators be doing in the classroom?

Before proceeding further towards evaluating employer needs in regards to critical thinking in the workplace, critical thinking itself should be defined and examined. The reader will find that critical thinking is a complex concept that has as many definitions as definers.

2.10 Critical Thinking

2.10.1 Definition

Critical thinking proves to be a difficult concept to define. Despite years of debate, no universal definition of critical thinking exists (Angelo, 1995; Pepa, Brown, & Alverson, 1997; Taube, 1995). Even so, it is useful to examine definitions of some of the more influential individuals in this field. We will find that most definitions focus on cognitive abilities and the use of such abilities to make choices and decisions. Blai (1989) describes critical thinking as the flagship of thinking skills. Most formal definitions characterize critical thinking as an intentional application of rational, higher order thinking skills, such as analysis, synthesis, problem recognition and problem solving, inference, and evaluation (Angelo, 1995). Defining critical thinking can be confusing since other closely related terms are often used synonymously. Terms such as
thinking skills, problem solving, creative thinking, and reasoning muddy an attempt to arrive at a clear definition. As we shall find, the literature most often lists critical thinking as the dominant term and others, such as creative thinking, as related to critical thinking. Some maintain that reflective thought or the creation of new ideas should be labeled creative thinking and conceived as different than critical thinking (Fulton, 1988). Beyond the simple acquisition of knowledge, a major aim in American higher education is to improve students’ abilities to think critically, to reason, and to evaluate and weigh evidence in making decisions and choices among alternative courses of action. This cluster of intellectual skills has often been labeled critical thinking ability (Pascarella, 1989). Thinking skills and critical thinking are held to be synonymous in this study and we shall place creative thinking as related to, but not the same as critical thinking.

There are variations on the definitions of critical thinking. Some view the concept as a product, an end result - critical thought; others champion the process - critical thinking (Fulton, 1988). Two of the most important individuals in this area are Watson and Glaser (1980), the developers of one of the most commonly used critical thinking assessment instruments, the Watson Glaser Critical Thinking Appraisal (WGCTA). Watson and Glaser (1980) believe CT is a composite of attitudes, knowledge, and skills that include three factors. First, CT involves attitudes of inquiry which involve an ability to recognize the existence of problems and an acceptance of the general need for evidence in support of what is asserted to be true. Secondly, CT includes knowledge of the nature of valid inferences, abstractions, and generalizations in which the weight or accuracy of different kinds of evidence are logically determined. Lastly, CT involves skills in employing and applying the above definitions and knowledge. This definition well represents the idea that critical thinking is a higher-order skill, one that is not universally possessed and could be cited as an example of the concept as product.

Halpern (1989) also emphasized the critical thinking as product concept. He described critical thinking as “thinking that is purposeful, reasoned, and goal directed. It
is the kind of thinking involved in solving problems, formulating inferences, calculating likelihood, and making decisions” (Halpern, p. 5). It could be argued that Halpern was really emphasizing the process here if one focuses on the verbs in his definition; solving, formulating, calculating, and making decisions. However, it appears that he is placing more weight on the products of critical thought; the problem solved and the decision made.

The American Philosophical Association sponsored a study on critical thinking that is known as the Delphi Report in 1990. Using the Delphi methodology developed by the Rand Corporation (Hostrop, 1973), a facilitator conducted an anonymous, iterative, two year inter-communication among 46 experts in CT across the United States and Canada until a consensus definition of CT was reached. The experts were drawn from Philosophy, Psychology, Education and a variety of other disciplines. The panel appears to have considered CT as a product by placing emphasis on the ends rather than the process of achieving the final result. Facione (1991) summarized the panel’s conceptualization of the critical-thinking construct.

We understand CT to be purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that consideration is based. CT is essential as a tool of inquiry. As such, CT is a liberating force in education and a powerful resource in one’s personal and civic life. While not synonymous with good thinking, CT is a pervasive and self-rectifying human phenomenon. The ideal critical thinker is habitually inquisitive, well informed, trustful of reason, open-minded, flexible, fair-minded in evaluation, honest in facing personal biases, prudent in making judgments, willing to reconsider, clear about issues, orderly in complex matters,
diligent in seeking relevant information, reasonable in the selection of criteria, focused in inquiry, and persistent in seeking results which are as precise as the subject and the circumstances of inquiry permit. Thus, educating good critical thinkers means working towards this ideal. It combines developing CT skills with nurturing those dispositions which consistently yield useful insights and which are the basis of a rational and democratic society (p. 2).

The Delphi Report’s expert consensus definition of CT represented the first time in history of the evolution of the construct of CT that such an accord has occurred. The consensus describes two dimensions of CT, the cognitive abilities dimension and the affective or dispositional dimension (Facione & Facione, 1994). These dimensions allow identification of skills possessed by those proficient in CT and permit description of those intellectual habits which characterize those persons adept at CT (Facione & Facione).

A recognized expert on critical thinking, Richard Paul, defines critical thinking as disciplined, self-directed thinking that exemplifies the perfection of thinking appropriate to a particular mode or domain of thinking, thinking that displays mastery of intellectual skills and abilities, and the art of thinking about your thinking in order to make your thinking better, more clear, more accurate, or more defensible (Paul, 1993). More specifically, Paul suggests critical thinking includes the following ideas (Paul, 1992):

The ability to formulate, analyze, and assess the (1) problem or question at issue, (2) purpose or goal of the thinking, (3) frame of reference or points of view involved, (4) assumptions made, (5) central concepts and ideas involved, (6) principles or theories used, (7) evidence data or reasons advanced, (8) interpretations and claims made, (9) inferences, reasoning, and lines of formulated thought, and (10) implications and consequences that follow (p. 11).
Paul is talking about a way of thinking; analyzing information, processing and evaluating that information, and finally, forming a judgment. No question that this ‘way of thinking’ is a higher order operation. Paul’s definition might be interpreted as an example of the view of critical thinking as process rather than product. Other authors also appear to consider critical thinking as process. Gray (1991, p.1) describes critical thinking “as the reasoning we do in order to determine whether a claim is true”. A similar definition is offered by Bell who states CT involves the ability to use reason in examining evidence (Bell, 1991). Lipman (1988) stated that critical thinking is “skillful, responsible thinking that facilitates good judgment because it relies upon criteria, is self-correcting, and is sensitive to context”(p. 39). Lipman compares ordinary thinking to good (critical) thinking by focusing on the differences in precision and rigor between the two (Lipman, 1988). Here the emphasis is clearly on the process. Kurfiss (1989) also suggests CT is a process in his definition of critical thinking:

(CT is) the process of figuring out what to believe or not about a situation, phenomenon, problem, or controversy for which no single definitive answer or solution exists. The term implies a diligent, open-minded search for understanding, rather than for discovery of a necessary conclusion (p. 42).

No mention is made of the product of critical thinking, the focus is on the path to the end, the process of thinking critically.

Some believe critical thinking is a two-part system. Critical thinking has been conceptualized as a two factor system in which critical-thinking ability and critical-thinking disposition combine to determine actual thinking performance (Taube, 1995). This is somewhat different than other definitions that focus strictly on ability to think critically.

Bloom’s Taxonomy of the Cognitive Domain has often been used as an example of what higher level learning, i.e. being able to think critically, exemplifies. It is cited so frequently in education discussions of critical thinking that it is worth mentioning here.
Bloom’s Taxonomy consists of six categories that represent a hierarchy of increasing levels of understanding. The six categories are knowledge, comprehension, application, analysis, synthesis, and evaluation (Bloom, Englehart, Furst, Hill & Krathwohl, 1956). The higher levels, the latter three, are of greatest interest to those examining critical thinking since it appears that to achieve the ability to analyze, synthesize, and evaluate, a prerequisite expertise in thinking critically is required. Although Nordvall and Braxton (1996) believe just analysis and synthesis involve critical thinking, this author fails to comprehend why evaluation is excluded. If Bloom lists his categories in hierarchical order and, if synthesis and analysis require critical thinking, then it follows that evaluation, an even higher skill, requires the ability to think critically.

Brookfield (1987) exemplifies another view of critical thinking as process. He defines critical thinking as a productive and positive emotive and rational process that occurs in contextually specific events triggered by both positive and negative life events (Brookfield). From this concept, he hypothesizes only four components of the process of critical thinking; (1) identifying and challenging assumptions, (2) challenging the importance of the context, (3) imagining and exploring alternatives, and (4) reflective skepticism (Brookfield). His definition might be considered too simplistic (Fulton, 1988), especially when compared with those of Watson and Glaser and Ennis, but his choice of verbs (challenging, exploring) emphasizes the ongoing nature of the concept of critical thinking.

If Brookfield’s definition could be considered too simplistic, the concept of critical thinking, according to Ennis, might be thought of as overly complex. Ennis (1985) offers the following as a definition of critical thinking:

Although there are narrower concepts of critical thinking in some people’s minds, I think that the one that is most generally employed is expressed in this definition:

**Critical thinking is reflective and reasonable thinking that is focused on deciding**
what to believe or do. Note that there are creative activities covered by this definition, including formulating hypotheses, questions, alternatives, and plans for experiments. Note also that, so defined, critical thinking is a practical activity because deciding what to believe or do is a practical activity (p. 45).

The underlined thought, the basis of his definition, seems clear and concise, but he attaches much to this beginning thought. “Deciding what to believe or do” (p. 45) is greatly expanded, but what results is a complex explanation of CT. Based on this definition, Ennis (1985) developed the following 13 dispositions

1. Seek a clear statement of the thesis or question
2. Seek reasons
3. Try to be well informed
4. Use credible sources and mention them
5. Take into account the whole situation
6. Try to remain relevant to the main points
7. Try to keep in mind the original and/or basic concern
8. Look for alternatives
9. Be open-minded
10. Take a position (and change a position) when the evidence and reasons are sufficient to do so
11. Seek as much precision as the subject permits
12. Deal in an orderly manner with the parts of a complex whole
13. Be sensitive to the feelings, level of knowledge and degree of sophistication
Ennis (1985) expands further by stating CT includes 12 abilities which are grouped into the following five categories.

1. Elementary classification
2. Basic support
3. Inference
4. Advanced clarification
5. Strategies and tactics (p. 45)

Elementary classification refers to asking a question, analyzing arguments, and asking and answering questions of clarification and challenge. Ennis’ basic support category is involved with judging credibility, observation, and judging observations. His third area, inference, is made up of several abilities: deducing and judging deductions, inducing and judging induction, and making and judging value judgments. Advanced clarification refers to defining terms and judging these definitions along with identifying assumptions. Finally, Deciding on a course of action and interacting with others comprise his strategies and tactics category. Comparing the categories with Ennis’ (1985) simple and concise statement of CT as deciding what to believe or do, it is clear the categories proceed in sequence. First, an individual considers information, analyzes a potential direction, rethinks the position, then finally acts.

We have seen in employer surveys references to critical thinking and creative thinking. They are related, but are not exactly the same. Norris & Ennis (1989) attempt to differentiate between the two concepts by first comparing CT in relation to all good thinking and this is illustrated in Figure 1. As Figure 1 illustrates, good thinking encompasses CT, that is, all critical thinking is good thinking, but only part of good thinking is CT. And CT can be either evaluative or nonevaluative.
Figure 1. Relationship of critical thinking to good thinking.

Similar to CT, creative thinking is also a part of good thinking and secondly, creative thinking can be reflective or nonreflective. This relationship between good thinking and creative thinking is illustrated from Norris & Ennis (1989) in Figure 2.

**Figure 2.** The relationship between creative thinking and good thinking.


When both critical thinking and creative thinking are compared together as part of good thinking, the relationship between the two becomes clearer. The overlapping area includes thinking that is reasonable, productive, reflective, but nonevaluative. This is illustrated in Figure 3.
Norris & Ennis (1989) describe their interpretation of the figure in the following manner:

Remember that the figure depicts the conceptual relationships involved. That is, it shows that critical and creative thinking are somewhat different, but overlapping; that both critical and creative thinking are completely included in good thinking; and that, even when taken together, critical and creative thinking do not comprise all of good thinking. The figure does not show, however, the interdependence of critical and creative thinking in real thinking situations. We
believe they are very interdependent (p. 19).

Because of the interdependence of critical and creative thinking, the two are often found together. However, if we follow the thinking of Norris and Ennis (1989), the two terms cannot be considered synonymous.

The Kellogg Center for Adult Learning Research, Montana State University, has defined critical thinking as part of a learning strategy instrument. Critical thinking is “a parallel process by which individuals analyze given information in a contextually specific situation and create new ideas, concepts, or constructs based on their analysis” (Fulton, 1988, p 6). The definition continues with the listing of four strategies the Kellogg Center believes are necessary for critical thinking (Fulton) which are identified as the analytical and creative aspects of critical thinking.

1) Recognizing and testing assumptions. These include those that are either implicit for the situation or explicitly stated. The critical thinker does not impose his/her own assumptions, but can identify those assumptions that are organizing the information presented and can then test those assumptions for validity in the specific context of that situation.

2) Assessing contextual parameters. The critical thinker can evaluate both the specificity of a situation as well as the universality of the situation. He/she recognizes both the limits of a certain situation as well as any generalizability always cognizant of cultural implications.

3). Generating and testing alternatives. Generating and testing alternatives allows the critical thinker to hypothesize and dream while at the same time grounding alternatives in the realities of the given situation-cultural and individual.

4). Conditional acceptance. This can also be identified as reflective skepticism which allows the critical thinker to avoid universal truth and unquestioned
answers. Rather than conceptualizing in black and white, the critical thinker sees the shades of gray. The critical thinker reasons in conditionals, if...then...statements rather than thou shalt commandments (pp. 6-7).

The Kellogg definition exhibits critical thinking as process and clearly delineates this process into two parts, the analytical and creative aspects. The critical thinker first must receive information, assess this information, and make some judgments about its worth and application. The creative aspect requires action. The critical thinker must act on the information received. Kellogg labels this the creative aspect since the thinker must hypothesize in an original manner, at least for the individual thinker (Fulton).

It is clear now why there is no generally accepted definition of critical thinking. Each of the experts cited has derived very different explanations of what critical thinking is and what it encompasses. This is not surprising since it is a complex concept that defies a simple definition. This is not a serious problem, but a workable definition is important if this study is to attempt to answer the research questions. What is important to this study is how business and industry defines critical thinking since it is this group that is the prime mover for school reform in the area of workforce readiness. When business speaks of problem solving, decision making, reasoning, and/or creative thinking, we can say they are talking about critical thinking. Educators also use these same terms when describing the critical thinking students should be able to do. This is the cluster of intellectual skills described by Pascarella (1989) that was mentioned earlier and is the foundation of the definition of critical thinking in this study.

Finally, we consider the SCANS Report’s definition of critical thinking. As previously mentioned, the SCANS Report (Department of Education, 1991, 1992) is the major work on the topic of workforce readiness. Since SCANS has been so influential, it is important to present the Secretary Commission’s description of what is critical
thinking. The SCANS definition is one of three divisions in the category of Foundation Skills. The division concerning this study is titled “Thinking Skills”, but as mentioned earlier, we are considering thinking skills and critical thinking to be synonymous. The topic “Thinking Skills” is divided into abilities; 1) the ability to learn, 2) to reason, 3) to think creatively, 4) to make decisions, 5) to solve problems, and 6) to visualize mentally (Department of Labor, 1992). The six are described in detail as follows (Department of Labor, 1991):

1) **Knowing how to learn** - uses efficient learning techniques to acquire and apply new knowledge and skills

2) **Reasoning** - discovers a rule or principle underlying the relationship between two or more objects and applies it in solving a problem

3) **Creative Thinking** - generates new ideas by making nonlinear or unusual connections, changing or reshaping goals, and imagining new possibilities

4) **Decision Making** - Specifies goals and constraints, generates alternatives, considers risk, and evaluates and chooses the best alternatives.

5) **Problem Solving** - Recognizes problems and implements a plan of action

6) **Mental Visualization** - organizes and processes symbols, pictures, graphs, objects, or other information (p. xviii)

Five of the six SCANS thinking skills are often included as part of the larger realm of CT as has previously been discussed. SCANS includes creative thinking in the list of thinking skills although Ennis (1985) does not consider creative thinking as part of CT. The SCANS list would be in agreement with Ennis if “thinking skills” were held to mean the “good thinking” Ennis identifies (see Figure 3).
It is now evident how difficult it is to try to define the complex topic of critical thinking. There seem to be as many definitions as there are definers. For the purposes of this investigation, critical thinking is considered the main term, the whole, which consists of many parts such as problem solving, creative thinking, decision making, reasoning, analyzing, synthesizing, and evaluating. These parts can be further divided into more specific mental abilities or skills, but will be considered part of critical thinking if related to, or derived from, the general divisions. Thinking skills is another term and is held to be identical to critical thinking. Whether critical thinking is a process or a product is a moot point. CT can be both process and product and are considered two aspects of critical thinking in this investigation.

2.10.2 Tests for Measuring Critical Thinking

It is worthwhile to examine CT tests and appraisals for they give insight not only into how critical thinking is currently measured, but also how it is expressed, at least on written tests. The measurement of critical thinking could theoretically come from a variety of approaches such as observation, interviews, and examination of written responses to open ended questions. However, these involve subjective judgments with likely reliability concerns. The objective question, written test increases the probability of reliable results and there is evidence that such tests at least partially reflect critical thinking ability (Miller, Sadler, & Mohl, 1993). Possibly this is the reason why all commercially available critical-thinking assessments are mostly multiple choice tests
based on general knowledge. There does not appear to be subject-specific tests although
the Test of Inquiry Skills contains sections that test for critical thinking in science and
social studies (Norris & Ennis, 1989). Most of the tests are comprehensive although a
few are aspect specific. If just defining critical thinking is difficult, it is reasonable to
expect that measuring critical thinking is an even more formidable task.

It shall become evident that critical thinking tests are not the same, that some are
more appropriate for specific applications than others. To help choose an appropriate test
for a specific purpose, Norris and Ennis (1989) have formulated a seven-step guideline
for examining critical thinking tests.

1. Pay close attention to the directions, the items, and the scoring guide.
2. Take the test yourself, and compare your answers with those of the guide.
3. Satisfy yourself that the scoring guide is reasonable, but do not expect to agree
   with it completely for any but deduction items.
4. Ask yourself often, “Does this really test for some aspect of critical thinking?”
5. For purported comprehensive critical thinking tests, ask yourself, “Does this
cover enough of critical thinking in a balanced manner to be called a
comprehensive critical thinking test?”
6. For purported aspect-specific critical thinking tests, ask yourself, “Does this
cover enough of the aspect?”
7. Read the test manual and note the statistical information, but remember the test
publishers have a conflict of interest in deciding what information to include and
exclude................... (p. 56).
Although it is possible to develop one’s own critical thinking test, it would likely be inferior to the commercially available tests, many of which have undergone years of refinement. Certainly when conducting research requiring measurement of critical thinking, the use of a widely applied and accepted commercial assessment would give the results far more credibility. There are about eight tests that measure critical thinking ability. First we shall examine the examples of comprehensive critical thinking tests

The Watson-Glaser Critical Thinking Appraisal

The oldest and most influential of the critical thinking tests is the Watson-Glaser Critical Thinking Appraisal (WGCTA). This is a multiple-choice test first developed in the 1930s by Goodwin Watson and Edward M. Glaser. The WGCTA was originally developed as a measure of the dependent variable in a major experiment designed to examine the effects of instructing high school students in critical thinking (Glaser, 1941). Through its various revisions it is probably the most extensively used critical thinking test and is a benchmark against which others must be compared (Adams, Whitlow, Stover, and Johnson, 1996; Landis and Michael, 1981; Norris & Ennis, 1989. Berger (1985) knows of no similar test that is on a par with the Watson-Glaser, but expressed concern over the narrow range of content included. Others have mentioned this narrow range of content (Crites, 1972; Dowling, 1989). Helmstadter (1985) described the WGCTA as a “good solid measure of adequate - but not outstanding - reliability”(p. 1693). Whoehlke (1985) criticized the available norms, but recommended the Watson-Glaser as the “best available instrument for measuring critical thinking” (p. 685).

The WGCTA has been normed on students from the ninth grade through seniors in college and is written at the ninth grade level. The most widely used version of the WGCTA consists of two parallel forms, A and B, and each is purported to test for the same aspects of critical thinking. Each form consists of five subtests; 1) inference, 2)
recognition of assumptions, 3) deduction, 4) interpretation, and 5) evaluation of arguments (Norris & Ennis, 1989). Each of these contains 16 items for a total of 80 items per test form. Test items in the newer form have been modified in the interest of clarity, current usage, and the elimination of racial or sexual stereotypes (Pearson, 1991). The subtests include problems, statements or arguments, and interpretations similar to those encountered at work, in the classroom, and newspapers and magazine articles on a daily basis.

The first subtest, inference, is designed to determine if the subject can judge a conclusion as true or false. Evidence is given to the subject in a short paragraph and the subject is instructed to regard the given information as true. A series of possible conclusions follow and the subject is asked to decide for each conclusion whether it is true, probably true, false, probably false, or lacking in sufficient information for a judgment (Norris and Ennis, 1989). Problems with this section involve the test taker’s knowledge about the situation described in the reading, individual creativity and interest, and the amount of time the person spends on the item. A sophisticated and experienced person might think of a variety of alternatives and select “insufficient data” when the WGCTA key hits “probably true” as the answer (Norris & Ennis).

The second section examines the ability to recognize unstated assumptions. Subjects are presented with a number of statements in which certain things are taken for granted. After each statement is listed some proposed assumptions are presented. The test taker must determine for each proposed assumption if it was, in fact, true.

The third subtest, deductive reasoning, presents the subject with a short paragraph and several possible conclusions that might be drawn from that paragraph. The object is to decide if each possible conclusion necessarily follows from the information in the paragraph.

The fourth subtest is interpretation. This section is similar to deductive reasoning in that evidence is considered to determine the acceptability of conclusions. However, in
this section the subject must decide whether conclusions follow beyond a reasonable doubt.

The final section of the WGCTA involves the ability to discern strong from weak arguments. Section Five consists of questions about important issues and a set of answers for each question. The answers either support or reject the original question and provide reasoning for each response. The reasons are assumed true and the subjects are to select their answer based on the strength of the reasoning.

The WGCTA requires different responses to different types of item content. Items having neutral content address topics such as the weather, scientific facts or experiments, and other subject matter about which people generally have no strong feelings or prejudices. Items having controversial content, although approximately parallel in logic structure to neutral items, address political, economic, and social issues that frequently provoke very strong feelings (Watson & Glaser, 1980).

In 1994 a new version of the WGCTA, designated Form S, was published. The purpose of form S is to provide the same information on critical thinking ability in a shorter time. Forms A and B require 40 minutes timed or 60 minutes untimed while Form S gets results in 30 minutes timed and 45 minutes untimed (Psychological Corporation, 2002). This form is a shorter version of Forms A and B. The authors suggest Form S can be used to select adult employees, do pre and post training evaluation, and perform career counseling, and employee development (Psychological Corporation, 2002). This Form mirrors Forms A and B by providing reading passages that include problems, statements, arguments, and interpretations accompanied by challenging questions. Likewise, a single score results that represents an individual’s ability to draw inferences, recognize assumptions, reason by deduction, interpret, and evaluate arguments. Again, Form S tests for the same abilities as A and B and is written at a ninth grade level. The appeal of this newest version is its ability to provide results in less time.
Cornell Critical Thinking Tests

There are really two Cornell Critical Thinking Tests (CCTT), Level X and Level Z and each is designed to test different educational levels and they do not cover exactly the same aspects of critical thinking (Norris and Ennis, 1989). These are multiple choice tests that purport to measure “general” critical thinking ability (Ennis, Millman, & Tomko, 1985). Level X is the easier of the two and is intended primarily for junior and senior high school students and first year college students. Level Z is designed for advanced and gifted high school students, college students, and adults.

Level X was designed to test interdependent aspects of thinking involving induction, deduction, judging observations, judging credibility, and identifying assumptions. These skills are assessed in four test sections presented within the context of a story about a group of explorers visiting a newly discovered planet in search of a previous group which has not reported back in two years (Frisby, 1991). The four sections include 1) inductive inference, 2) credibility of sources and observation, 3) deduction, and 4) assumption identification (Norris & Ennis, 1989).

Level X consists of 71 multiple-choice items divided into the four sections listed above. The task in Section I is to determine whether pieces of evidence discovered by the search party are 1) evidence for, 2) evidence against, or 3) neither evidence for or against the idea that the members of the first group are all dead. In Section II statements made by members of the search party are presented in pairs, and examinees are asked to determine which, if either, of the statements is more believable (Norris & Ennis, 1989).

Level Z is a 52 item multiple choice paper and pencil test. The items are arranged in sections with each item offering three possible answers. The questions are presented in seven sections; 1) deduction, 2) meaning, 3) credibility, 4) inductive inference (direction of support), 5) inductive inference (prediction and hypothesis testing), 6) definition and
unstated reasons, and 7) assumption identification (Norris & Ennis, 1989). In sections Ia and Ib, an ongoing debate between two persons is presented prior to each item. For each item, respondents are asked to indicate whether the conclusions highlighted within the debate: (a) follow necessarily from premises, (b) contradict premises, or (c) neither follow nor contradict premises (Frisby, 1991). In Section II each item presents a gradual unfolding of a different ongoing debate between two persons. Respondents are asked to choose among three reasons why one person’s thinking is faulty. Section III, IV, and V require subjects to answer items based on a description of the method and results of a scientific experiment. Section VI represents an ongoing discussion between two persons. Respondents must indicate which of three choices most accurately reflects the intended definition of a word used in the dialogue. Section VII also presents an ongoing discussion between two persons. For each item, respondents must state which of three statements best represents an unstated assumption in the discussion (Frisby).

Both tests X and Z share the same manual and the same philosophy about areas of proficiency of a critical thinker. The manual of the CCTT characterizes a critical thinker as having proficiency in judging whether (Norris & Ennis, 1989):

1. a statement follows from the premises
2. something is an assumption
3. an observation statement is reliable
4. an alleged authority is reliable
5. a simple generalization is warranted
6. an hypothesis is warranted
7. a theory is warranted
8. an argument depends on an ambiguity
9. a statement is overly vague or overly specific

10. a reason is relevant (p. 62)

The origin of the Cornell Tests dates to the fifties and sixties and, as a result, there is much information about the Tests. Reliability estimates for Level X range from .67 to .90 and for Level Z range from .50 to .77 (Norris & Ennis, 1989). The manual contains an extensive amount of information such as empirical research on the tests, correlations of the tests with other variables, factor analysis, and results of experimental studies of critical thinking.

California Critical Thinking Skills Test

The most recent CT test is the California Critical Thinking Skills Test (CCTST). The CCTST consists of Form A, developed in 1990, and form B, developed in 1992. Both forms are said to be statistically equivalent (Facione, 1991). The CCTST is the result of conceptualization of critical thinking which emerged from the two year Delphi research project sponsored by the American Philosophical Association (Facione). This test is an objectively scored standardized instrument which addresses the cognitive skills dimension of critical thinking and is aimed at college level subjects.

The CCTST is thought to be similar to the WGCTA because they both measure a broad spectrum of CT traits (Adams et al., 1996). Because it is new, the CCTST lacks the years of external research validation that the WGCTA has accumulated. However, the pilot instrument was constructed from a pool of 200 items developed over a twenty year research program aimed at validly and reliably testing critical thinking (Facione & Scherer, 1978).

Form A of the CCTST was constructed using the bank of 200 multiple-choice items. From these 200, 34 items were selected and designated Form A. The 200 items
had been previously analyzed for their ability to discriminate well between individuals and also selected for their high item-total correlations (Facione & Facione, 1994). The items were written using common, every day terms using familiar topics and social issues. The strategy was to prevent advantages or disadvantages to persons who may happen to have, or not have, special knowledge of specific academic disciplines. The CCTST score is the simple sum of the correct items. However, the 34 items can be scored to provide three sub-test scores; Analysis, Evaluation, and Inference. Thirty of the items can be scored to yield two sub-test scores; Deductive Reasoning and Inductive Reasoning (Jacobs, 1994).

The authors of the CCTST agree with Watson and Glaser in their definition of these five areas within the context of the instrument. Analysis is defined as comprehension and interpretation of meanings relating to a variety of experiences and relationships. Evaluation denotes plausibility of statements and the results of one’s reasoning. Inference means the ability to draw conclusions. Inductive reasoning is defined as conclusions made from inferences as compared to deductive reasoning which refers to drawing conclusions based on logical reasoning (Watson & Glaser, 1980; Facione & Facione, 1994).

Form B of the CCTST was developed by rewriting 28 of the 34 items from Form A by substituting different terms, names, contents, and contexts while attempting to maintain the type of topic or problem involved. Also the specific behavior assessed by the original item was retained. The original order of items in Form A, as well as position on the page, item length, and other appearance factors were unchanged on Form B (Jacobs, 1994). This represents a deliberate attempt by the authors to construct an
equivalent, or parallel, form. As previously pointed out, the authors make the argument that Forms A and B are equivalent on conceptual grounds.

Because the CCTST is so new, there is much less empirical research on validity and reliability issues. The pilot test was administered to a group of 1196 college students at California State University Fullerton. The subjects were divided into two groups; pre-test, post-test, and case control. The experimental group was comprised of students enrolled in any of four courses fulfilling the campus critical thinking requirement while the control group was made up of students who had not fulfilled the CT course requirements, but were enrolled in the course “Introduction to Philosophy”. The pilot investigation was administered under conditions similar to conditions for which the test was designed, i.e., a college classroom within a 45-minute time limit.

The results report scores approximating the normal distribution. The content validity of the CCTST is said simply to rest on the relationship to the Delphi Report research (Facione & Facione, 1994). Evidence of concurrent validity of the CCTST connect CCTST scores with other measures of college students aptitude and achievement. Test authors claim significant correlation with college level grade point average (.200, p< .001), SAT verbal (.550, p< .001), SAT math (.439, p< .001), and Nelson-Denny Reading scores (.200, p< .001) (Facione & Facione, 1994). The Kuder-Richardson internal reliability coefficients computed for each of the sections of the divided sample ranged from .68-.69 (Facione & Facione, 1994). This reported Kuder-Richardson coefficient is acknowledged to be low, but the test authors argue this is a respectable value given the constraints of the test. One measure mentioned as likely to result in increased reliability, increased test length, was dismissed since this would require a greater time frame than the
45 minutes the authors wished to retain. Facione and Facione conclude that significant gains in CT scores by the case group as compared to the control group were reported, but fail to provide the data.

The previous three tests, the WGCTA, the CCTT, and the CCTST are the major tests of CT in use. Although they are the most important in terms of frequency of use, there are several others not as well known. For comparison purposes, it is worthwhile to examine some examples.

**Ross Test of Higher Cognitive Processes**

The Ross test assesses the subject’s ability to analyze, synthesize, and evaluate, identical to the higher levels in Bloom’s Taxonomy of Educational Objectives. This test was designed by John D. Ross and Catherine M. Ross, introduced in 1976, and published by Academic Therapy Publications of Novato, California (Norris & Ennis, 1989). It is aimed at students in grades four through six and consists of 105 multiple-choice questions. The Ross test includes the following eight sections and is designed to be completed in two hours.

1. Analogies
2. Deductive Reasoning
3. Missing Premises
4. Abstract Relations
5. Sequential Synthesis
6. Questioning Strategies
7. Analysis or Relevance and Irrelevant Information
8. Analysis of Attributes (p. 69)
The eight sections are designed such that sections 1, 3, and 7 test the ability to analyze, sections 4, 5, and 8 are devoted to synthesis, and evaluation is tested in sections 2 and 6. This is a test of cognitive processes and there is some concern that certain categories do not appear to be critical thinking and the test provides minimal coverage of some aspects of critical thinking (Norris & Ennis, 1989). Norris and Ennis “feel the Ross test is too much like an IQ test to serve as a standard critical thinking test, but the correlation between the Ross test and the Lorge-Thorndike IQ test is low; so, maybe our intuitions are inaccurate” (p. 72).

Statistical information was derived from a comparison of gifted and non-gifted students. Reliability estimates are reported as .92 for split-half and .94 for test-retest. This is quite high. Norris and Ennis (1989) offer the following explanation for this unusually high reliability:

1. The large number of items (105) and generous amount of testing time;
2. The heavy use of deductive reasoning, which usually provides the most consistent answers on critical thinking tests;
3. The use of abstract content about which students do not have differences in backgrounds beliefs;
4. The similarity of some sections to sections of intelligence tests which tend to have higher reliabilities than critical thinking tests (p. 72).
New Jersey Test of Reasoning Skills

This test was devised by Virginia Shipman in 1983 at the Institute for the Advancement of Philosophy for Children, Montclair State College and is aimed at grades 4 through college. It is a lesser known test designed specifically for the Philosophy of Children program. It is not called a critical thinking test, but is designed to test reasoning in language. It consists of twenty-two skill areas with a theoretical average of slightly more than two multiple-choice questions per skill for a total of fifty questions. However, about half the items are concerned with deduction. Norris and Ennis (1989) argue that this heavy proportion of deduction questions reduces the Test’s value as a comprehensive critical thinking test. Deduction is an essential part of critical thinking, but probably not half of it (Norris & Ennis). The reported reliability statistics range from .85 for fifth grade to .91 for seventh grade (Norris & Ennis). The test is divided into two major classes; reasoning skills and inquiry skills.

Ennis-Weir Critical Thinking Essay Test

The Ennis-Weir Critical Thinking Essay Test (EWCTET) differs from other CT tests in its format. As the name implies, the Ennis-Weir test is an essay test. It is the only CT essay test and is also unique in that it tests for some critical thinking dispositions. It is designed for high school and college students.

The EWCTET is written in the form of a letter to the editor of a fictitious newspaper. The letter contains eight paragraphs in which the author argues for eliminating overnight parking in the make believe town of Moorsburg. The subject’s task is to respond to the thinking expressed in the letter by writing an evaluation of the
thinking in each of the letter writer’s eight paragraphs and an evaluation of the thinking in the letter as a whole (Norris & Ennis, 1989).

It may seem that an essay test would provide problems in scoring and in reliability between scorers. However, the Manual provides detailed descriptions of possible student responses and how to score them. The authors claim that, once the manual is understood, the responses are easy to score and can be evaluated at the rate of six per hour. The authors mention that some flexibility is allowed in grading to accommodate “good thinking” that was not anticipated or described in the manual. They claim that this flexibility “provides for handling varying levels of sophistication and varying background beliefs among examinees” (Norris & Ennis, 1989). This aspect seems to strengthen the test’s validity since real-life demands for critical thinking rarely result in the clear-cut right or wrong answers often found in multiple choice tests (Werner, 1991). The authors report reliability estimates of .86 and .82 based on interrater comparisons (Norris & Ennis). This indicates that different graders tend to rank students the same, but the scores may vary widely.

The validity issue is addressed by pointing out how the test’s letter to the editor compares to typical real-life situations in which critical thinking is needed. The authors appear to be satisfied that the test is valid simply because the hypothetical situation mirrors a genuine possibility that requires CT skills in order to respond in an adequate manner. This sounds somewhat too simple although their argument has intuitive appeal.

**Summary of Popular Critical Thinking Measurement Tests**

Six popular CT tests were describe previously. All have drawbacks characteristic to written tests and many of these were mentioned along with other concerns unique to
specific tests cited in the literature. Still, anyone wishing to measure CT in a population must use an instrument and must choose from those available, or possibly make up their own. Although this is possible, it appears to this writer advisable to choose from among the commercially available tests. To construct and use a new CT test would invite intense scrutiny on instrument validity and reliability issues that would draw attention away from the research question at hand and could taint results. A summary of the six CT tests is provided in Table 17.

Table 17

*Comparison of Six Commonly Used Critical Thinking Tests*

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Primary Audience</th>
<th>Format</th>
<th>Subheadings</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>WGCTA</td>
<td>High school and college students</td>
<td>Forms A, B</td>
<td>Inference</td>
<td>.70 - .82</td>
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<tr>
<td></td>
<td></td>
<td>Multiple choice</td>
<td>Recognition of assumptions</td>
<td></td>
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<td></td>
<td></td>
<td>80 items – 40 min.</td>
<td>Interpretation</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Form S – 30 min</td>
<td>Evaluation of arguments</td>
<td></td>
</tr>
<tr>
<td>EWCTET</td>
<td>High school and college students</td>
<td>Essay</td>
<td>Getting the point</td>
<td>.86 - .82</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Timed-40 min</td>
<td>Seeing the reasons and assumption</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Stating one’s point</td>
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<tr>
<td></td>
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<td>Offering good reasons</td>
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<td></td>
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<td>Seeing other possibilities</td>
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<td></td>
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<td>Equivocation</td>
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<td></td>
<td></td>
<td></td>
<td>Irrelevance</td>
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Table 17 (continued)

<table>
<thead>
<tr>
<th>Test</th>
<th>Age Group</th>
<th>Form</th>
<th>Type</th>
<th>Time</th>
<th>Level</th>
<th>Questions</th>
<th>Reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCTST</td>
<td>College aged</td>
<td>Forms A &amp; B</td>
<td>Analysis</td>
<td>.68 - .69</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Individuals</td>
<td>Multiple choice</td>
<td>Evaluation</td>
<td></td>
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<td></td>
<td></td>
<td>34 items</td>
<td>Inference</td>
<td></td>
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<td></td>
<td></td>
<td>45 minutes</td>
<td>Inductive</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Deductive</td>
<td></td>
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<tr>
<td>CCTT</td>
<td>Grades 7-12 &amp; first year college</td>
<td>Level X &amp; Z</td>
<td>Induction</td>
<td>Level X</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Multiple choice</td>
<td>Deduction</td>
<td>.67 - .90</td>
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<td></td>
<td></td>
<td>Level X – 71 items</td>
<td>Value judgment</td>
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<td></td>
<td></td>
<td>Level Z – 52 items</td>
<td>Observation</td>
<td>Level Z</td>
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<tr>
<td></td>
<td></td>
<td>50 minutes</td>
<td>Credibility</td>
<td>.50 - .77</td>
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<td></td>
<td></td>
<td>Assumptions</td>
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<tr>
<td>RTHCP</td>
<td>Grades 4-6</td>
<td>Multiple choice</td>
<td>Analogies</td>
<td>.92 - .94</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>105 items</td>
<td>Deductive reasoning</td>
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<td></td>
<td></td>
<td>Two settings</td>
<td>Missing premises</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>one hour each</td>
<td>Abstract relations</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Sequential synthesis</td>
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</tbody>
</table>
Table 17 (continued)

<table>
<thead>
<tr>
<th>Questioning strategies</th>
<th>Analysis of relevant and irrelevant information</th>
<th>Analysis of attributes</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>NJTRS</th>
<th>Grade 5 and up</th>
<th>Multiple choice</th>
<th>Seeking criteria for cognitive inquiry</th>
<th>.85-.91</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50 items</td>
<td></td>
<td>Ordering and sorting</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Discerning relationships</td>
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<td></td>
<td></td>
<td></td>
<td>Inferring</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Skills of reasonable discussion</td>
<td></td>
</tr>
</tbody>
</table>

**Note.** WGCTA = Watson-Glaser Critical Thinking Appraisal; EWCTET = Ennis-Weir Critical Thinking Essay Test; CCTST = California Critical Thinking Skills Test; CCTT = Cornell Critical Thinking Test; RTHCP = Ross Test of Higher Cognitive Processes; NJTRS = New Jersey Test of Reasoning Skills.

The test subheadings give an indication of the CT definitions of the test authors. The complexity of defining CT is exhibited in the variety of areas tested by the different tests. As expected, the definitions of CT offered by Ennis and Watson and Glaser compare with the subheadings of their respective tests. However, Ennis’ summary definition of CT, deciding what to believe or do, is too simple to be inferred from the many subheadings of the EWCTET. Using “deciding what to believe or do” as a base, it could be argued that Ennis views CT as a product and his test’s many subheadings measure ones ability to negotiate the pathway leading to deciding what to believe or do.
Watson and Glaser (1980) also indicate they view CT as a product, but their five subheadings do not clearly indicate this. The subheadings of the CCTST, the RTHCP, and the CCTT hint that the authors consider CT a process, but the authors of the NJTRS clearly favor the process view with their use of verbs. The abstractness of CT makes it both difficult to define and difficult to measure.

Which of the commercially available CT tests is the best? Which test to use depends on the goals of the researcher. Novice researchers, such as this writer, can avoid, or lessen, criticism of their results and conclusions if a widely applied and accepted CT test is used. In addition, factors such as cost, time for completion, and ease of scoring are important. The Watson-Glaser Critical Thinking Appraisal Form S appears to be the best choice of a research instrument from those examined. As mentioned before, the WGCTA is the oldest and most widely used of the CT tests and has been described as “the best available” critical thinking test. Using it will likely give more credible results than a lesser known and less widely used instrument and it is easily administered and scored.

When considering testing both science students and employees to measure CT, the age and maturity of individuals, appropriateness of material, and time for administration should be considered. For ninth grade students and above, Form S of the Watson Glaser Critical Thinking Appraisal appears to be a good choice. Form S is more attractive to this writer since it is identical to the widely used Forms A and B, but allows results to be obtained in a shorter time. The shorter administration time likely would be an attractive feature for businesses which test for CT in their pre-hires. No references in the literature were found to indicate Form S is any less valid or reliable than Forms A and B although it should be pointed out that Forms S has only been in existence for ten years. Level X of the Cornell Critical Thinking Tests is also appropriate for this same age group of students. The California Critical Thinking Skills Test, however, is aimed at the college level. For elementary students, the Ross Test of Higher Cognitive Processes is a reasonable choice, but one is cautioned about the criticisms previously mentioned. The
Ennis-Weir Critical Thinking Essay Test might attract attention of language arts teachers because of the essay format of this test. Critical thinking and writing ability might both be measured simultaneously and, if given as a pretest and posttest, could possibly be used to measure overall learning if writing and CT improvement were goals of the course.

2.10.3 Critical Thinking and the Classroom

Although it may appear that instruction to improve critical thinking is a recent phenomenon, the idea has been around for centuries. Plato argued that training in mathematics is especially important for improving thinking skills, “Arithmetic stirs up him who is by nature sleepy and dull, and makes him quick to learn, retentive, and shrewd. He makes progress quite beyond his natural powers” (cited in Mann, 1979, p. 125). In the late Sixteenth century Sir Francis Bacon suggested that mathematics be used to help with lack of attention:

If a boy has a light, inattentive, inconsistent spirit, so that he is easily diverted, and his attention cannot easily be fixed, he will find advantage in mathematics, in which a demonstration must be commenced anew whenever the thought wanders even for a moment. (Cited in Mann, p. 332).

Nineteenth century educators favored Latin over mathematics for stimulating thinking skills. They argued that the challenges of learning Latin were excellent for developing skills to learn new information (Mann, 1979). In 1910, John Dewy advised that the sole direct path to enduring improvement in the methods of instruction and learning consists in centering upon the conditions which exact, promote, and test thinking (Cited in Piro & Iorio, 1990). The latter part of this century has seen educators move
beyond the teaching of Latin and promote a wide variety of strategies and teaching methods. As the Twentieth Century closed, technology, specifically the computer, has become a tool often suggested for stimulating CT. Thus, the development of CT has been regarded for many years as one of the major goals of education (Resnick, 1987) yet evidence indicates students seem not to have acquired the ability to think well (Kuhn, 1990).

**Can Critical Thinking Improve Through Formal Instruction?**

Cannot students learn critical thinking skills on their own as a peripheral benefit of traditional instruction? Some believe the answer is no. It appears to some that critical-thinking skills do not develop unless explicit and deliberate efforts are invested in developing them (Zohar, Weinberger, & Tamir, 1994). Research indicates that explicit and deliberate efforts have shown success. Several studies indicate that learning experiences explicitly designed to develop thinking skills can achieve their goals to various degrees (Blai, 1992; Crow & Haws, 1985; Freidler & Tamir, 1986; Hanley, 1995; Kaplan & Kies, 1995; Pappalis, Pohlman, & Pappalis, 1980; Rief & St. John, 1979; Shayler and Adey, 1992; Sternberg, 1984; Wheatley, 1975). However, Inlow and Chovan (1993) concluded that the implementation of a thinking-skills program offers little assurance that thinking or problem-solving skills of college students will improve. The phrase “to varying degrees” indicates that success may not be universal or complete. On the other hand, some researchers have found evidence that traditional, formal education has a positive effect on CT improvement without specific CT instruction (Klassen, 1983; Steward & Yousef, 1989; Yoesting & Renner, 1969). Just as motivated individuals can
learn skills on their own outside of the formal classroom, it is probable that some have become adept at CT on their own. Certainly there are adults who could earn a ‘high’ score on the WGCTA and have not had formal instruction in CT.

The complexity of critical thinking that makes the concept difficult to define also frustrates those who attempt to examine CT teaching and learning. Previously cited surveys and studies indicate that the learning of critical thinking is a 'good thing'. Most of the early support has suggested the acquisition of CT skill has been thought to make an individual a better citizen and it has been only relatively recently that employers have called for emphasis on CT for practical reasons. Some perceive great benefit for gifted students (Burns & Reis, 1991). Others feel all students can benefit from CT instruction (Barrickman, 1997) and still others feel even at risk students will also benefit (Campbell & Chastain-Bogy, 1996). As a result of this interest in CT, there has been much research over the years. Unfortunately, there is no clear picture about teaching and learning CT. Often good sounding suggestions are presented for teaching CT, but most are lacking in hard data. Where data exist and are easy to obtain, the research is often flawed in design and control (Sternberg & Bhana, 1986). CT curricula are, to a greater or lesser extent, beset by at least one of the following limitations: substantial gains tend to show up only for some students, under the tutelage of only some teachers, and only on tests that are closest in structure and content to the course itself (Asams, 1989).

There have been many, many attempts to incorporate CT study in the classroom. Some focus on using CT strategies to increase performance in traditional subject matter while other approaches seek to increase the CT skill level of students with the goal that they will be able to transfer their learning to practical situations in their lives, present and
future. It will be helpful to examine a selection of CT teaching strategies to provide a basis of understanding.

One of the more popular programs encompassing CT that has demonstrated quantifiable success is the HOTS (Higher Order Thinking Skills) project developed in the early eighties by Stanley Pogrow (Crump, Schlichter, & Palk, 1988; Pogrow, 1993, 1988). HOTS was developed to help Chapter 1 students more fully utilize their abilities in ways that traditional methods could not. Current theories of cognition were used to design an alternative approach in which all the supplemental time used for drill on basic skills would be used to enhance general thinking ability (Pogrow, 1990). This was carried out by combining the use of computers with Socratic teaching to stimulate the development of the following four general thinking techniques (Pogrow, 1990):

1. Metacognition - consciously applying strategies to solve problems.
2. Inference from context - figuring out unknown words and information from the surrounding information.
3. Decontextualization - generalizing ideas from one context to another.
4. Synthesis of information - combining information from a variety of sources and identifying key pieces of information needed to solve a problem (p. 390).

The goal of HOTS was to increase thinking-skill performance with the goal of raising content learning. During the first year there were few direct connections to traditional content because the curriculum focused on the process of thinking rather than content. Pogrow did not have students apply their new thinking skills to formal classroom content until the end of the second year. The HOTS ideas were more recently focused on the learning of mathematics with the intent of increasing students’
understanding of mathematics concepts (Pogrow, 1994).

The HOTS project has been adopted in many school districts, over 2000 by 1997, and studies indicate success. One conclusion is that a thinking-skills program can improve achievement in the basic skills at least as much as a good remedial approach, probably more (Pogrow, 1990). Pogrow (1990) reports standardized reading and mathematics gains between fall and spring of more than 15 percentile points, gains that exceed that national average. Studies have shown simultaneous improvements in six categories: basic skills, writing skills, metacognition skills, grade point average, key IQ components, and ability to solve new problems (Pogrow, 1996, 1997). Unfortunately, the work of Pogrow is one of the very few bright spots in this field.

Two studies concerning science teaching and learning disagree concerning the premise that specific teaching strategies increase CT. In a study supported by hard data, Agne and Blick (1972) concluded that earth science students taught using original data in a research approach technique showed significantly greater improvement in CT than a control group taught in the traditional manner. However, Charen (1970) compared CT scores on the WGCTA between the experimental group exposed to open-ended, directed, observation type experiments and a second group taught in the traditional manner. The traditionally taught students exhibited a significantly higher score than did the experimental group. These two studies are both rare and noteworthy because they actually have quantifiable results.

Other attempts have failed or have had mixed results at best. Most often strategies are suggested on their intuitive worth alone with no data to support claimed effectiveness. Littlefield, Delclosa, Bransford, Clayton, & Franks (1992) evaluated
claims suggesting that learning the programming language LOGO can enhance students’
general thinking skills and found little evidence of transfer to non-LOGO problems.  
Garret, Schoener, and Hood (1996) suggest debate is an effective educational process for
promoting critical thinking and verbal communication skill. They cite the use of debate
in various historical settings and present ideas to incorporate debate in a curriculum, but
offer no data suggesting debate is effective in increasing CT ability. Carr (1988)
suggests using activities based on Bloom’s Taxonomy while Chiras, (1992) provides a
specific list of rules for teaching CT in science classes. A novel approach for increasing
thinking skills using Bloom’s taxonomy and comic strips is suggested by Sherman and
Wright (1996). They cite several studies indicating children’s interest in comic strips
plus other studies that attest to the comics’ flexibility for instructional use. Although
Sherman and Wright offer suggestions on how to teach CT with Schultz’s Peanuts, no
data was presented to demonstrate the effectiveness of their ideas. The use of the
Socratic method to further CT by asking students probing questions to justify their
positions and arguments is suggested by Schoeman (1997). However, Beyer (1985)
earlier cited research that casts doubt on the extent to which hierarchies of teacher asked
questions teach any particular thinking skills at all. Beyer goes on to explain that such
questions may exercise student thinking, but even then one cannot be sure which
particular aspects of thinking are being exercised. Several other approaches for teaching
CT include the use of hands-on and mental activities based on the higher levels of
Bloom’s taxonomy (Whittington, 1993), correlational reasoning problems (Ross and
Smythe, 1995), and logic problems (Sadler, 1993). More approaches include writing
(Ocens, 1996; Wade, 1995), cooperative learning (Cooper, 1995), story telling (Irwin,
1996), use of quality circle strategy (Kaplan & Kies, 1995), use of paradoxes (Eliason, 1996), and literature discussion groups and journaling (Esplugas & Landwehr, 1996; Romeo & Young, 1997). Each of these strategies has one glaring fault. None of the authors offer any data to suggest their strategies effectively increase the level of critical thinking.

Despite the great volume of literature on the subject of teaching of critical thinking, there is no agreement on what works. With the possible exception of the HOTS project, successes have not been universal or even common. When some limited success is documented, the transfer of apparent CT ability to new situations is limited or nonexistent. Despite overwhelming agreement that teaching and learning CT is a valuable endeavor and needed in the working world, educators seem unable to get the job done. What has gone wrong?

What has gone wrong with the teaching and learning of critical thinking?

It is important to the purpose of this study to examine in some detail possible explanations why the teaching of CT has not been successful. Both teachers and textbook writers have made a serious effort to teach for thinking (Sternberg & Martin, 1988), yet success seems so elusive. The suggestion that CT teaching and learning is not meeting expectations was described over a decade ago (Beyer, 1984). Beyer lists five major reasons why educators have not put to better use the time we devote to teaching thinking.

1. We do not agree among ourselves which thinking skills we should teach.

2. Too many educators and developers of educational materials do not understand - or have not defined precisely - the skills that they have elected to
teach.

3. Despite their best intentions, most teachers never provide the kinds of instruction that research suggests are most productive in developing competent thinkers.

4. School curricula too frequently suffer from “skills overload; they bombard students with one shot exposures to literally dozens of skills at each grade level, apparently on the assumption that children can master these skills on first introduction.

5. The achievement tests currently in use in many schools may actually inhibit the teaching and learning of thinking skills; at the least, they hinder the consistent evaluation of the students’ competence in these skills (p. 486).

Both teachers and textbook writers believe they are teaching CT, but when asked if students are learning, teachers and writers are less certain (Sternberg and Martin, 1988). These two researchers present four models that explain the possible shortcomings that so many educators have experienced when trying to increase the CT ability of their students.

The four models are based on a water hose analogy, one that compares lack of success concerning CT teaching with the inability of a water hose to spray water (Sternberg & Martin, 1988)

Model 1. The dry-well model. Teachers and textbook writers may be trying to teach for thinking, and may think they are teaching for thinking, but they are wrong. The substance is just not there. Good intentions are no substitute for good results.
Model 2. *The depressed water spigot model.* Teachers are teaching for thinking, but they are not doing nearly enough of it. In essence, the water pressure is not turned up high enough. What they see as sufficient instruction to get results may be in fact far less than would be needed in order to produce real improvements in students’ thinking skills.

Model 3. *The holey hose model.* Teachers are teaching for thinking and are doing enough of it, but much of what they are doing is effectively going in one ear and out the other. The material never makes it all along the way from input from the teacher to the student to output from the student to the teacher. There are leaks along the way. Given the complexity of the internal mental processing of the material taught, it would scarcely be surprising if some of it were lost from the time the student receives it to the time the student needs to use it.

Model 4. *The no good nozzle model.* Teachers are teaching for thinking and students are absorbing what they are teaching, but they are unable to use what they have learned. The knowledge—both procedural and declarative—is available, but not accessible. In other words, the students have inert knowledge they are unable to use at the appropriate time and in the appropriate place. (Sternberg & Martin, 1988, pp. 556-557)

Instruction that does not promote critical thinking. The first model refers to good intentions, but poor results. Teachers are trying to teaching for thinking, or so they believe; yet in reality little teaching for thinking is taking place. It is well known that most instruction is given in *lecture or didactic style.* This style is useful in presenting new information to students who are expected to absorb it. There is little opportunity or
time for student reflection or discussion of the lesson. Likewise there is little or no opportunity for growth in CT since students are not expected to do any thinking at all. A second teaching style is the common question and answer teaching strategy. It can be labeled the *fact-based questioning approach* (Sternberg & Martin, 1988). The teacher asks questions that require the student to respond with factual information which the teacher acknowledges as right or wrong. With this second teaching style students do have the opportunity to participate, but since the answers are fact-based and geared to memorization of content, there again is minimal opportunity for improvement of CT. However, this style is effective in reinforcing newly learned information. A third teaching style is most conducive to improvement in CT and has been called the *thinking-based questioning approach* or *dialogical* approach (Sternberg & Martin). Students are asked to give opinions, to make judgments, and to defend their positions. The teacher’s role is to lead the discussion and comment on and add to what students have said.

Although the dialogical style as presented by Sternberg and Martin is the best of the three for promoting CT, it should be pointed out that the other two styles are not poor. Each has merit. The strength of the didactic style is in the presentation of new information. The fact-based questioning alternative does well at reinforcing newly learned information and testing student knowledge.

Those who have spent time in the classroom either as teacher, student, or observer realize that the greatest quantity of teaching time is in the didactic style with a lesser amount devoted to fact-based questioning. Very little dialogical or thinking-based questioning is done (Kloss, 1988). Daines (1986) has reported that 93% of the questions asked by elementary and secondary teachers were at the literal level of comprehension,
and 88% of the students’ answers, regardless of the teaching style and grade level, were also at this, the lowest level of cognitive skills. If CT is good and thinking-based questioning demands critical thinking on the part of the students, then why is there so little thinking-based questioning?

Incorporating dialogical or thinking-based questioning into the curriculum is difficult and uncomfortable for both students and teachers (Sternberg & Martin, 1988). Students are familiar and comfortable with the first two styles and respond reasonably well to them. When the dialogical approach is attempted the common response is silence. Students are not familiar with this style of interaction, are unprepared to do the thinking it requires or to take the risks that it involves (Sternberg & Martin). Silence is the result and silence is uncomfortable for both students and teachers. When this occurs it is all too easy to revert back to styles one and two. However, teachers who want to teach thinking should expect some discomfort. For style three to succeed, a fairly drastic reorientation in notions about the teaching-learning process must take place, because the students’ expectations and notions of what classroom events are like can interfere with the transmission of thinking skills (Sternberg & Martin). The students’ unfamiliarity with thinking-based questioning and the resultant lack of comfort provides an explanation why less teaching for thinking occurs despite the best of intentions.

Too little exposure to critical thinking. In their model, Sternberg and Martin (1988) maintain students are not getting enough exposure to critical-thinking material and activities. One impediment to teaching critical thinking concerns the way CT is presented in textbooks. Most science textbooks have some sections devoted to stimulating student thinking skills. However, the bulk of the chapters and units address factual content and
any thinking-skills material is often isolated, or insulated, from the main body. The implicit message is that thinking-skill material is basically separate from the main body of material, and is perhaps viewed as, at best, an enrichment of that material that is separate from that material itself (Sternberg and Martin). Most often thinking-skills material is placed at the end of a chapter. This isolated placement of CT material prohibits students from practicing skills as they learn. In addition, given the over optimistic quantity of material to be taught, these isolated bits of thinking-skill activity are often omitted when time runs short as is very often the case.

It has been stated that producing good critical thinkers is the goal of CT instruction. There is benefit for the individual if he or she can apply CT skills to real problems in the “real-world”. No one argues against this goal, but often CT instruction frequently has little relevance to real-world problems. Textbook writers often derive their lists of thinking skills from taxonomies of Bloom and Hunter in such a way that one problem may be analysis, another application, etc. This is a mistake (Sternberg & Martin, 1988). These two researchers maintain that virtually no practical problems in life can be solved so neatly. Real-world problems require a combination of process and skills, and indeed, much of the difficulty of typical problems is in knowing how to combine the appropriate processes and skills (Sternberg & Martin). This is no more evident than in the teaching of mathematics, particularly calculus. Students are expected to learn calculus principles in small bits, the chain rule today, implicit differentiation tomorrow. Yet knowing the chain rule, implicit differentiation, and the many other reduced skills will not help the student solve an industrial problem requiring calculus unless he or she can combine the skills with understanding and choose the operations appropriate to the
problem. When CT skills are taught in a fragmented manner, the desired transfer to real problems cannot be expected.

**Ineffective teaching for critical thinking.** Few teachers have any formal instruction on how to teach CT. Those that attempt to provide instruction that emphasizes and improves student critical-thinking ability often fail because of ineffective strategies (Beyer, 1984; Sternberg & Martin, 1988). Nickerson (1984) wrote that evidence regarding effectiveness of specific programs for teaching thinking was sparse. Not much seems to have changed in the last 20 years. Though many programs purporting to increase CT ability have been developed in recent years, few, if any, can provide research that suggests effectiveness. One of the better and more widely used programs is called Tactics for Thinking (Arrendondo & Marzano, 1986) and is used to teach teachers how to instruct their students in CT. It is designed to use real problems with examples on how to incorporate them into the formal curricula. Although popular and intuitively attractive, this writer is not aware if any studies exist to demonstrate the effectiveness of Tactics for Thinking.

**Failure to transfer learned critical thinking skills to new situations.** The lack of transfer of what the student is taught to applications outside the classroom is a common and persistent problem with CT strategies. Sternberg and Martin (1988) suggest much of the transfer dilemma concerns the kinds of problems presented to students when attempting to teach thinking skills.

Sternberg and Martin (1988) suggest the following as an explanation for the lack of transfer of formal CT learning to real-world situations.
1. In the everyday world, the first and sometimes most difficult step in problem solving is the recognition that a problem exists.

2. In everyday problem solving, it is often harder to figure out just what the problem is than to figure out how to solve it.

3. Everyday problems tend to be ill structured.

4. In everyday problem solving, it is usually not clear what information will be needed to solve a given problem nor is it always clear where the requisite information can be found.

5. The solutions to everyday problems depend on and interact with the contexts in which the problems are presented.

6. Everyday problems generally have no one right solution and even the criteria for what constitutes a best solution are often not clear.

7. The solutions to everyday problems depend at least as much on informal knowledge as on formal knowledge.

8. Solutions to everyday problems have consequences that matter.

9. Everyday problem solving occurs in groups.

10. Everyday problems can be complicated, messy, and stubbornly persistent (pp. 572-576).

It should not be surprising that the ability to apply CT skills learned in the classroom is difficult for students if Sternberg and Martin are correct. There may be too large of a gap between the problem situations given to students and what they encounter in everyday life. What knowledge they construct to solve the defined, structured CT
problems in the classroom, is often too far removed from ill-defined, unstructured situations faced outside the classroom. Students can’t make the leap.

When attempting to teach CT, we give students problems or situations in which the problem, or question to be answered, is clearly identified, the information required for solution is readily available, and usually there is only one right answer, or at least one best solution. Each problem presented is unrelated to others; solve one and go on to the next. Formal CT problems are clean and neat.

When comparing the types of situations students are given with those they face out of school, or those they certainly will face as adults, there is a clear lack of relevancy. This is Sternberg and Martin’s (1988) point. Schools would better serve students if CT exercises were more aligned with the type of problems they find, and will find as adults, in everyday life. Is there such a program that provides more relevant CT learning? Two strategies for the Teaching of CT skills follow as illustrations.

Four Pronged Model for the Development of Intellectual Skills

Sternberg and Davidson (1984) originally proposed the following instructional model in an unpublished manuscript. This model has had some success in the 80s for conveying thinking skills in a variety of substantive domains and contains four sequential steps: 1) direct instruction, 2) intragroup problem solving, 3) intergroup problem solving, and 4) individual problem solving (Sternberg & Davidson).

Direct instruction. To overcome the deficiencies of non-relevant examples, students are presented with two or three everyday problems, the solutions to which require the use of the thinking skill or skills that have been introduced. Relevance is very
important if transfer is to occur. Sternberg and Davidson (1984) address the transfer issue by admitting that students may fail to see the point, that is, they may fail to see the relationship between the problem and the CT processes and strategies to be used for solution. If the connection is not made, students will not transfer the thinking processes and strategies to new situations. Thus, justifying examples and emphasizing how the examples fit into the teacher’s goal of transmitting some information or skills seem to be critical for the effective use of examples in the classroom (Sternberg & Davidson).

The teacher presents problems in a didactic manner, but the path to solution proceeds more according to the thinking-based questioning approach. The goal is to have students use the targeted thinking process or processes.

After being guided into problem solution using specific mental processes, students are asked to analyze their thinking processes. The goal is to put them rather than the teacher in the position of generating the concept or concepts that the teacher wishes to teach (Sternberg & Davidson, 1984). The premise here is that students learn more effectively when the learning is active and constructive rather than in the traditionally passive manner. The teacher assigns a common term to label and identify the relevant processes to be taught. Sternberg and Davidson suggest that this labeling step will facilitate conceptualization and communication in subsequent class problem solving.

The teacher relates a newly learned process with other processes previously presented. Sternberg and Davidson (1984) point out the importance of this step by arguing that relating new processes to old facilitates students’ development of integrated cognitive structures regarding thinking skills.

The teacher presents further practical examples from everyday life. Here the
students are expected to seek solutions in terms of the processes previously taught. That is, they are asked to pay as much attention to the thought processes used as to the solution itself. Sternberg and Davidson (1984) suggest that problem solving is an integrated activity, and requires putting together a variety of processes and skills, not all of which could possibly be taught in a single day.

Sternberg & Davidson (1984) suggest student self-generation of processes for problem solving encourages them to be active and constructive learners. However, the processes need to involve those taught. By using practical examples from everyday life, there is greater success possible for transfer from the problems presented them to problems they face in their everyday lives.

**Intragroup problem solving.** The authors maintain intragroup problem solving can generate brainstorming that is useful after direct instruction. Students, as common in brainstorming sessions, should be encouraged to express their ideas and not be concerned whether their ideas are reasonable or make sense. Sternberg and Martin (1988) suggest this step is valuable for developing the higher order process involved in planning solutions, but it is not useful in developing higher order processes involved in monitoring and evaluating situations. The following step accomplishes this end.

**Intergroup problem solving.** Sternberg and Martin (1988) use intergroup problem solving to develop monitoring and evaluation skills. They suggest assigning two or more groups the same problem, then each group presents its solution to the others. Finally the other group or groups evaluate each solution presented. Another technique is to have two or more groups devise alternative solutions to the same problem. In both techniques, students gain experience and practice in evaluation of complex ideas in a group setting.
Individual problem solving. The final step in Sternberg and Martin’s model involves problem solving by the individual. The premise is that individuals solve problems best if they internalize the best elements of what they see happening interpersonally in social situations (Vygotsky, 1978). By doing the group work first, the student has an opportunity to view the problem solving processes of others. Then the student can apply those that are best for problem solution.

Sternberg and Martin’s (1988) explanation of the errors of CT teaching make much intuitive sense. What they contend does agree with what many have experienced. However, their model was so general as to be generally ineffective for implementation by the average, untrained teacher. This model is claimed to be effective, but no studies were cited to support their claim. A more detailed and research supported strategy follows.

A more widely known and used strategy for teaching thinking is the Tactics for Thinking program developed by Arrendondo and Marzano (1986). It is presented as a tool for teaching thinking from K-12 and consists of 22 skills or tactics. After receiving training in Tactics for Thinking, teachers are encouraged to use the skills in their classrooms and then participate in the decision about which skills are best suited to their needs, their students, and to their specific teaching style (Arrendondo & Marzano). Arrendondo and Marzano maintain Tactics for Thinking is distinguished from other programs by the several assumptions upon which the program is based.

The teaching of thinking should be overt, teacher directed, and part of regular classroom instruction (Arrendondo & Marzano, 1986). This involves explicit instruction for specific cognitive operations. The 22 skills are the cognitive operations taught with this program by the regular classroom teacher. The authors believe there is nothing
magical about the 22 skills. These skills are a starting point. Students should be encouraged to develop their own processes after exposure to Tactics for Thinking. Tactics for Thinking is a framework for instruction. The teacher is the important factor in this program. There is less reliance on paper and pencil activities and more emphasis on the interaction between teacher and student. The teacher provides direction, framing the lesson so that content is learned and thinking skills are reinforced.

Tactics for Thinking is designed to be taught and reinforced as part of the regular curriculum as a way of teaching and learning content. The basic assumption is you cannot separate the teaching of thinking from the teaching of content (Arrendondo & Marzano, 1986). CT involves thinking about something and for students this something is the content of the regular curricula. It is believed, or at least hoped, that content learning will improve as a result of learning better cognitive skills.

Successful students have acquired essential thinking skills outside the classroom (Arrendondo and Marzano, 1986). Many students do demonstrate very good cognitive skills. If they have been exposed to no, or little, explicit teaching of cognitive skills, then they obviously must have picked these up on their own perhaps outside the formal classroom. However, as the drop rate attests, there are many students who are unable to learn these skills on their own. For these students, a specific program for the teaching of cognitive skills should have benefit.

The direct teaching of thinking skills within formal education will necessitate a change or restructuring of curricula, instruction, and assessment techniques (Arrendondo & Marzano, 1986). The direct teaching of thinking skills places educators in an arena where they must confront basic beliefs, values, and unstated assumptions about what is
taught and how it is assessed (Arrendondo & Marzano). One outcome of inclusion of Tactics for Thinking is the exclusion of some factual content in favor of topics more conducive to the use of thinking skills. Finally, fact based tests might give way to more problem solving evaluations.

Tactics for Thinking skills are divided into three general areas: 1) learning-to-learn skills, 2) content thinking skills, and 3) reasoning skills (Arrendondo & Marzano, 1986). These three are in order from the simplest to the most complex. The learning-to-learn skills include the first six of the 22 skills and are general skills that apply to a variety of tasks both within formal education and out of school. These are considered so essential that it is suggested the learning-to-learn skills be taught in the beginning of the school year along with the rules and procedures important to classroom management. The second group, content thinking skills, refers to the next six skills that are especially designed to increase student’s ability to learn academic content. These concept attainment and pattern recognition skills allow academic content to be organized and presented as concepts, patterns, and procedures. Having gained some expertise in the basic and content skills, the student focuses on the remaining ten higher order thinking skills. These ten also are in a specific order. Basic reasoning and evidence examination are among the first of the ten. The highest and most difficult to attain thinking skills, problem solving and invention, are the last skills. These ten are often presented as enrichment skills used to challenge students and reinforce the content.

Although no data is presented to support the effectiveness of Tactics for Thinking, much research is cited as support for the listed skills and philosophy. Each of the 22 skills lists 4-6 references supporting the value of the skill and the overall philosophy of
teaching thinking skills is also supported. These citations are included only in the instructor’s manual (used for teaching teachers) and not in the teachers manual (used for teaching students). Very few, if any, thinking skill strategies are so well supported by research. Overall, Tactics for Thinking is a well designed, well researched strategy for teaching thinking, but studies are needed to measure its effectiveness.

Summary of critical thinking and the classroom

The topic of teaching and learning CT is complicated and confusing. Many studies offer suggestions to improve CT ability, but most are lacking in data suggesting effectiveness. The best explanation of why CT teaching and learning has not been universally successful and the best strategy presented for improving CT teaching and learning is in the work of Sternberg and Martin (1988). This is a field that needs a great deal more study.

2.11 Connection between the Workplace, Critical Thinking, and Science Education

The relationship between the global economy, the new or high-performance workplace, and greater critical-thinking ability in employees has been established in previous sections. Science education has the potential for improving the critical-thinking ability of students because of the nature of science. Science has always relied on creative and critical thinkers to make discoveries (pure science) and to make practical use of new knowledge (applied science).
Unfortunately, science educators frequently lose sight of the creative and critical thinking aspects of science by providing student learning experiences requiring little, if any, thinking. Teachers talk, students listen. As Sternberg and Martin (1988) point out, science instruction remains mostly recall. Memorization of science facts and concepts is the most common activity of science students. This is well documented (Daines, 1986). The school science laboratory, lauded as the place for hands-on science, is often criticized for “cook book” labs, or as some lament, hands on - minds off activities. Despite the difficulties in teaching towards thinking previously mentioned by Sternberg and Martin, science education offers great opportunity for increasing critical thinking ability. Although the literature does not present clear evidence that teaching for thinking actually increases critical thinking ability, no one has argued against it.

This writer will offer one example of how a science learning activity can be constructed to stimulate CT. A freshman college chemistry course at a major university presented to students during the Winter 2000 Quarter a lab titled simply, The Air Bag. Students were given two ziplock bags, modest quantities of 0.50 M HCl and solid NaHCO₃ and were instructed to carry out a reaction in the bag that will just fill the bag with a gas. No other directions were given. They must design the experiment as a collaborative effort with their partner. This is a simple lab requiring only a few minutes to complete, but without directions, it becomes a challenging exercise in thinking ability.

In order to meet the objective of generating exactly the amount of gas to fill the volume of the bag, the student arrives at two realizations and undertakes several steps. First, the student must realize the following:
1. HCl and NaHCO₃ react to form CO₂ and an aqueous solution of NaCl and water.

2. The problem is a combination gas law/stoichiometry exercise.

After realizing what will take place, the following steps must be taken to meet the objective.

1. The volume of the bag must be determined (water and graduated cylinder).
2. Using PV=nRT, solve for moles (n), adjusting volume to STP.
3. Using n, solve for mass of NaHCO₃ and volume of 0.50 M HCl.
4. Recalculate volume after considering the volume of water in solution after reaction.
5. Recalculate n and mass of NaHCO₃ and volume of HCl.
6. Place reactants in bag such that the reaction does not begin until the bag is sealed.
7. Mix contents to begin reaction.

In the beginning of the lab session the students showed hesitation and uncertainty. One or two attempted to get some guidance from the professor, but were told to proceed on their own. As Sternberg and Martin (1988) predicted, both lab sessions experienced a time of awkward silence as students struggled formulating their plan. The first lab was small, only five students, and an hour passed before one discovered he could find the volume of the bag by using water and the graduated cylinder. The others saw this, followed the example, and smoothly proceeded to a solution. The 15 students in the second lab proceeded more quickly because of a nontraditional student who figured out how to determine bag volume in only about five minutes. As in the first lab, once the
volume of the bag was determined, students collaborated to construct a plan leading to a

Having studied gas law problems and stochiometry, most freshman college chemistry students would have little difficulty completing this lab if it were presented in the traditional format. Most science students are able to carry out a series of given steps, make observations, and gather physical data. Educators are aware, however, that students often mechanically carry out procedures without gaining the deeper understanding of the concept. Little thinking is needed to follow directions; it has already been done for the student. By requiring students to design their own procedure, two benefits arise; (1) students are forced to think critically about what to do, and (2) students must have or develop a conceptual understanding in order to decide what to do.

It is much easier for both the teacher and students to teach and learn science at a simple recall and application level. The chemistry example resulted in frustration and required much extra lab time to complete. However uncomfortable, it was hoped that the experience was of greater benefit than a traditional lab.

The Airbag lab is similar to the kinds of problems adults encounter on the job. Although research shows little, or no transfer between learning activities promoting critical thinking and on-the-job problems requiring critical thinking, few studies have examined this relationship. Employers say they want employees who are better thinkers. Science educators have the opportunity to promote critical thinking through redesigned learning activities similar to the Airbag lab. This is an area that needs more research.

The learning attained by students has been measured for decades by grades and the diploma at the end of their high school career. This has been satisfactory until in
recent years graduates deficient in ‘skills’ have come to the attention of the public. Business and industry leaders have applied pressure on state legislatures across the country to hold schools accountable for the quality of their graduates. State education standards and proficiency tests were developed to provide this accountability for both schools and students.

This push for more accountability has occurred in Ohio as in almost all states. The Ohio Legislature has directed the Ohio Department of Education to construct methods of assessments to measure the academic achievement of Ohio students across the curriculum at designated times in the students’ school careers. The last test for Ohio students is the 12th Grade Proficiency Test although passing is not a graduation requirement. This study is concerned with the critical thinking required on the Science Section of the Ohio 12th Grade Proficiency Test.

2.12 The Ohio Twelfth Grade Proficiency Test

As of Summer, 2003, the most important test for Ohio students is the Ninth-Grade Proficiency Test. This is the test which all sections must be passed in order to graduate from high school. The Twelfth-Grade Proficiency Test is taken by seniors who have passed all areas of the Ninth-Grade Test. Some have labeled this test the “Honors Test” since successful completion allows a graduating student to earn a Diploma with Honors.

The Ohio Department of Education will phase in the Ohio Graduation Test in 2005 eliminating both the Ninth and Twelfth Grade Proficiency Tests. Political pressure
has postponed this implementation. The last year for the Ninth Grade Test was originally scheduled for 2001.

This study was begun when the Ohio 12th Grade Proficiency Test was the final test and this study examines the Science Section of this test in detail. The fact that the Ohio Department of Education will soon use the new test does not make this study’s analysis obsolete. The very version of the Science Section of the 12th Grade Test that this study analyzes is the exact same version provided to science educators as an example of what to expect on the science section of the Ohio Graduation Test.

The Science Segment of the Twelfth-Grade Test was the last area to be included, first added in the 1995-96 school year. Science was not a factor in earning the Diploma with Honors until the 2000-2001 school year.

2.12.1 Learning Outcomes

A committee of primarily Ohio educators developed the science test based on eighteen learning outcomes (See Figure 4). The test was adopted by the Ohio State Board of Education in 1994. The work by the committee was based on the Ohio Model Competency-Based Science Program and other related documents and emphasizes both content and process. Questions developed from the learning outcomes emphasize basic facts, understanding of concepts, and ability to analyze and apply information in a given situation (Ohio Department of Education, 2000a). The three kinds of questions are described below.
Acquiring scientific knowledge. This section comprises about 30% of the test and question students’ abilities to make observations and collect and organize data. This may include the ability to make measurements: read graphs, charts, and tables; and classify objects based on their characteristics (Ohio Department of Education, 2000a).

Processing scientific knowledge. Questions of this type test students’ abilities to interpret and analyze information. This may include the ability to make an inference from given information; recognize patterns and trends in data; use mathematics and mathematical models in science; and manipulate variables (Ohio Department of Education, 2000a).

Extending scientific knowledge. Questions of this type test students’ abilities to apply knowledge and concepts to new situations. This may include students’ abilities to develop models; draw conclusions; ask and evaluate questions; and make predictions (Ohio Department of Education, 2000a).

It can easily be seen that the Science segment does not rely on simple recall questions. A deeper understanding of science concepts is required. The Department of Education (2000a) emphasizes that student preparation for this test is a process that begins in kindergarten and continues throughout a student’s school experience. In general, this proficiency test is designed to assess long-term student learning-problem solving and thinking skills-and is not limited to rote knowledge and facts (Ohio Department of Education, 2000a).

Some general suggestions are given to guide educators in designing the science curriculum for their schools. As with the eighteen learning outcomes, the suggestions are also based on the Ohio Science Model. The learning required on the Twelfth-Grade Test
is best achieved through hands on experience, the use of authentic science sources including, but not limited to, library references, textbooks, on-line sources, experts, and long-term activities as students ask questions, collect and analyze data, and make decisions (Ohio Department of Education, 2000a). Less important than memorizing facts is the student’s abilities to use process and analysis skills. The more experience students have with collecting and analyzing data and information, and justifying their answers, the better prepared they will be for the Twelve-Grade Science Segment (Ohio Department of Education, 2000a).

2.12.2 Science Areas

There are four areas of science included on the Science Segments and these are described below.

**Life science.** Though life sciences are often the most familiar, this program strikes a balance between the life science concepts that are extremely complicated and laden with terminology with those that can be directly observed and explored by students. In these outcomes, (6, 14, 16, 17, and 18 in Figure 4), students’ abilities to explain their choices and decisions are more important than their knowledge of terminology (Ohio Department of Education, 2000a).

**Physical science.** Commonly thought of as physics and chemistry, physical science for this level includes physical principles that can be observed and explored and the inferences that can be made based on concrete experiences in the classroom or
witnessed by other means without complicated instruments or theories (Ohio Department of Education, 2000a). Outcomes 1, 2, and 3 in Figure 4 relate to this area.

Earth and space science. Many of the phenomena of earth science are either too slow or too large to witness directly in action. Instruction for these outcomes (9, 10, and 11 in Figure 4) generally involve events that students can witness either directly or indirectly through television or film (Ohio Department of Education, 2000a).

Nature of science. Built into this science test is an assessment of students’ abilities and thinking habits in investigating science ideas. Seven outcomes (4, 5, 7, 8, 12, 13, and 15 in Figure 4) in this strand overlap traditional science units and each other and should therefore be reinforced throughout the science curriculum – i.e., taught in context – at every grade level, in nearly every unit (Ohio Department of Education, 2000a).

As mentioned previously, the test is designed around eighteen learning outcomes. All eighteen are listed in Figure 4 as described by the Ohio Department of Education (2000a).

1. **Trace energy transformations, and/or apply the principles of mass/energy conservation to physical and biological systems.**

   Identify the changes in the forms of energy within a system.

   Students should be able to distinguish between different forms of energy, such as potential and kinetic, and should be familiar with the conservation of energy in living and non-living systems. Students should also be familiar with concepts related to waves, such as frequency and wavelength. Students should be familiar with thermodynamics, how to measure energy, and how to evaluate the energy and mass relationships of a system.
2. **Utilize models of atomic and molecular structures and/or interactions to explain, interpret, or predict experimental results.**

   "Explain how a chemical reaction occurs on a molecular level."

Students should have a basic understanding of models of atomic and molecular structure, and how these models can be used to explain the structure and interactions of matter. This includes concepts such as bonding, reaction kinetics, molecular shape, periodicity, equilibrium, gas laws, phases of matter, atomic theory, and stoichiometry.

3. **Use fundamental forces to explain and make predictions about motion and changes in systems**

   "Explain how the path of a thrown ball can be predicted and why the ball falls towards the ground."

Students should be familiar with the relationship between changes in motion of an object and the forces applied to the object and the mass of the object. Students should be familiar with concepts such as forces that cause motion, the four fundamental forces, the effects of the forces, vector analysis, and Newton’s three laws of motion.

4. **Analyze the results of changing a component of simple systems.**

   "Explain and predict how a change can affect a system like a lake, a machine, or a mountain range."

Students should be able to recognize and evaluate the effect(s) of changing a component of a biological, chemical, electrical, geological, mechanical, or optical system. This includes concepts such as equilibrium, homeostasis, and system dynamics.

5. **Relate structure and function in physical and biological systems.**

   "Use the structure of wings and feathers to explain why birds can fly."
Students should be able to recognize and have a basic understanding of the shape, material properties, position, and durability of components of systems as related to function. would include such things as how geometric shape affects the strength of structures, as in buildings and bones, and how chemical structures relate to uses, such as polymers, enzymes, and crystals. Students should be able to recognize that the results of forces acting on matter throughout the universe are, to a large extent, both measurable and predictable.

6. **Predict the effect on an ecosystem due to a given or proposed environmental change.**

- *Identify how an environmental change will disrupt the balance of an ecosystem.*

Students should have a basic understanding of the interrelationships between living and nonliving components of ecosystems. This includes the concepts of trophic structure, food webs, and interactions between species. Students should also be able to understand how environmental changes, both biotic and abiotic, may effect an ecosystem. This includes concepts such as species introductions, extinction, pollution, and changes in abiotic factors, such as rainfall and temperature, or the impact of the human population on the environment.

7. **Evaluate the scientific validity of data used in persuasive communication.**

- *Evaluate the advertising claim of a soap product.*

Students should be able to evaluate the use of scientific information in persuasive communications, such as advertisements, periodicals, public information, and political statements. For example, if students are given a newspaper report relating to science, they should be able to evaluate the validity of the information in the report.

8. **Formulate an experimental design to test a given hypothesis.**

- *Design an experiment that will test an idea.*

Students should be able to design experiments to test a given idea and analyze the results. Students should be familiar with the scientific method and the concept of a control.
9. Demonstrate an understanding of the impact of natural phenomena on the Earth’s geological formations over short and long time spans.
   
   Explain how and why mountains, rivers, and lakes change.

Students should be familiar with the theory and processes of weathering, erosion, glaciation, rock formation, geochemical cycles, and plate tectonics (vulcanism, earthquakes, rifting, mountain building, etc.). Students should understand how earth-changing processes are reflected in the geomorphology of the Earth’s surface.

10. Analyze and interpret meteorological data and predict weather for a specified location.

   Use data to predict weather.

Students should have a basic understanding of weather and climate. Students should be able to interpret meteorological charts and maps to analyze local weather conditions and global weather patterns.

11. Relate planetary cycles and observations to natural phenomena including seasons, tides, days/nights, phases of the moon, and eclipses.

   Explain the tides or an eclipse of the sun.

Students should be familiar with the concepts of axial tilt, rate of rotation and revolution, orbital shape, and gravity. Students should understand how these factors are related to phenomena on Earth, such as seasons and tides.

12. Demonstrate an understanding of units of measure and precision by using an appropriate measuring device for an application.

   Identify the appropriate instrument needed to make a given measurement.

Students should be familiar with the uses of common laboratory devices, such as balances, graduated cylinders, and rulers.
Students should be able to use the International System of Units and other measurement systems as appropriate to science topics.

**13. Identify the safety precautions that should be taken given a Material Safety Data Sheet (MSDS) or a product label with a key.**

*Know how to interpret safety precautions given on an MSDS or product label.*

Occupational safety regulations, and safety concepts in general, involve the management, storage, and disposal of materials that may be in use at work or at home. MSDS are available from material suppliers or from the main office of any workplace in Ohio. Students should be able to interpret and use the information on the MSDS or a product label and identify appropriate safety precautions that should be followed.

**14. Relate the effects of biotic and abiotic factors to animal life including growth, reproduction, and behavior.**

*Describe how living and nonliving factors (like fleas and floods) can affect animal life.*

Students should have a basic understanding of animal biology at the molecular, cellular, tissue, organ, individual, population, and ecological levels. This may include homeostatic mechanisms.

**15. Demonstrate an understanding that scientific theories and methods have developed and continue through time.**

*Describe how explanations of eclipses have changed over time.*

Students should have an understanding of the tentative nature of science including how and why scientific theories and methods have changed over time. This may include, but are not limited to, models of the solar system, germ theory, models of the atom, heat, elements, and genetics.

**16. Relate the effect of light and other factors on the various aspects of plant life and growth including photosynthesis and respiration, germination, and tropisms.**

*Describe how light and water affect plants.*
Students should have a basic understanding of plant biology (including algae) at the molecular, cellular, tissue, individual, and ecological levels. This may include homeostatic mechanisms.

17. **Relate patterns of diversity, extinction, adaptation, and speciation as a result of natural selection at the molecular and population levels.**

   *Explain why maple seeds that spin as they fall.*

Students should have a basic understanding of the structure and function of DNA, protein synthesis, heredity, and genetic variability. Students should also have a basic understanding of change through time and natural selection, which contribute to species survival, adaptation, and extinction.

18. **Relate biodiversity to the stability of ecosystems within biomes.**

   *Explain why a forest is more stable than a cornfield when a plant disease occurs.*

Students should have a basic understanding of how diversity (number and variety of species) affects the stability of ecosystems within biomes. This includes the issue of species interactions.

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From “Fact sheet: Twelfth-grade proficiency test in science” by The Ohio Department of Education, 2000, p. 3.

The entire Science Section is presented in Appendix G to allow the reader the opportunity to examine each question him or herself. Although questions change from one version to another, the Ohio Department of Education maintains each version follows the general format mentioned earlier.

Each version of the test includes questions from the four areas of science and most of the eighteen learning outcomes. Table 18 presents an analysis of the scope of the
Science Section.

Table 18

*Summary of Scope Analysis of One Version of the Science Section of the Ohio 12th Grade Proficiency Test*

<table>
<thead>
<tr>
<th>Science area</th>
<th>Nature of science</th>
<th>Physical science</th>
<th>Earth science</th>
<th>Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of questions</td>
<td>11</td>
<td>15</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level of usage</th>
<th>Communications</th>
<th>Evidence of inquiry</th>
<th>Relevance to society</th>
<th>Depth of understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Questions</td>
<td>14</td>
<td>13</td>
<td>11</td>
<td>12</td>
</tr>
</tbody>
</table>

*Note.* Adapted from Ohio Graduation Test by Ohio Department of Education, 2000b.

Table 18 includes information from an early publication of the Ohio Graduation Test which is not yet in use. What is noteworthy about this test is the fact that the science section of this test is exactly the same as the science section of the Ohio 12th Grade Proficiency Test used in this study.
This chapter has focused on a number of topics. The changing workforce, the skills gap of employees, critical thinking (definitions, assessment, teaching strategies), and criticism of the schools for failing to produce graduates with skills employers require are important topics still much in the news. Several landmark studies indicate the skills gap is real and at least one of these studies has caused widespread change in school curricula and implementation of school-to-work programs. However, other evidence was presented that suggests the issue is more related to work ethic than the higher-level skills so often reported as lacking. At least one study cited, which concludes the existence of a skills gap, is seriously biased and severely flawed. The question of whether a skills gap exists has not been satisfactorily answered.

One of the skills always mentioned as lacking in skills gap research is critical-thinking ability. Often included in the broader category of thinking skills, critical thinking is deemed by experts to be a very important and desirable skill. It is a skill employers say they desire in their workers. Much emphasis has been placed on encouraging more teaching and learning of the ability to think critically, but both educators and business people express dissatisfaction with the level of CT exhibited by students and entry level employees.

All these topics merge on the Proficiency Tests. Designed to measure what a student should know and be able to do upon graduation, passing the Ohio 12th Grade Proficiency Test should be a credential indicating a student has met a certain level of achievement. He or she is now ready to move on to higher education or directly into the
job market. This test, and others, were designed and implemented as a response to criticism by the business community over the perceived lack of skills, including critical thinking.

This study addresses several of the questions and contradictions brought forth in this chapter. Workplace skills, critical thinking, the proficiency tests, and science curricula are topics that are both interrelated and important to those in business and education.
CHAPTER 3

METHODS AND PROCEDURES

3.1 Population

The target population of one section of this study was all businesses in the state of Ohio who advertise in the Yellow Pages or business sections of Ohio telephone directories. For the analysis of the 12th Grade Proficiency Test, one copy was chosen for examination. The State of Ohio Department of Education claims that different versions of the test are comparable.

3.2 Sample

From the target population, a sample of 500 Ohio businesses who advertise in the Yellow Pages or business sections of Ohio telephone directories, was chosen at random. Business Directories of Omaha, Nebraska was contracted to use their data base of all Ohio businesses to randomly select the sample so that each member of the target population had, as close as possible, an equal, non-zero chance of being selected in the sample. A
questionnaire was used to elicit responses of sample employers concerning general questions about their business and specific questions concerning the use of critical thinking by their employees.

3.3 Instruments

3.3.1 Employer Questionnaire

An 18-question employer survey was designed to provide data to answer the research questions. The entire questionnaire can be found in Appendix C. Questions 1-3 were designed to seek information about the size and type of the business and an estimate of how many job applicants are rejected for each open position. This information provides an idea of how prospective employees view the attributes of the company as a place to work. The greater the number of applicants rejected, the more favorably applicants view this company. The converse might also be true, the less applicants rejected, or if positions are unfilled, prospective employees might view a company as a less desirable place to work.

Question 4 provides insights into what the respondent believes are the major problems with personnel. Recall that the literature is uncertain whether a gap in skills exists or a lack of old fashioned work ethic is the greater problem. This question provided the respondent with the opportunity to identify his or her company’s position on this important issue. Also Question 4 allowed the respondent to state whether or not his or her company’s level of skill required of entry-level employees is rising. A rising skill level was identified in the literature as a characteristic of companies in the New Economy
and a reason why schools must do a better job of educating our young people.

The remaining questions deal specifically with critical thinking used on the job. Question 5 begins the inquiry by simply asking the respondent whether or not his or her company tests pre-hires for critical-thinking ability. The answer provides an indication of how important the company views critical-thinking ability in their employees. If a CT test is administered, it probably means CT is an important attribute for their employees. Questions 6 and 7 are closely related to the new economy/new management style discussed at length in Chapter 1. The goal was to determine how common the new management style is in Ohio businesses. Recall the literature places great emphasis on the premise that greater critical-thinking ability is needed with the new management style. Both questions offered two choices; one describes a management attitude characteristic of a traditionally managed workplace and the other characteristic of a new management workplace. The sequence of choices was switched for the two questions. For example, the responses identified with new management procedures were 6b and 7a, while the traditional management responses were 6a and 7b.

Question 8 attempted to ascertain the level of critical thinking required in Ohio workplaces. The greatest level of critical-thinking ability would be that required in deciding what to believe or what to do in totally new situations. This was choice A. A lesser degree of CT would be required of those whose must decide what to believe or what to do over a narrow range of reoccurring situations, choice B. The third response identified the lowest level, that which no critical thinking is required of the employee. He or she must only follow the established procedures devised by the employer.

Question 9 was designed to discern the number of Ohio employers who encourage
talented employees to advance to higher levels within the company. In order to prepare the thinking of the survey participants to answer questions 11-14, question 10 asked the respondents to identify the specific entry-level job he or she would place an individual in who demonstrated an ability to think critically. The respondent was to answer questions 11-14 in reference to the one position he or she listed in question 10. This was done to help provide some clarity and focus for the survey participant.

Questions 11-14 were designed to seek correlation, if any, between science objectives or learning outcomes listed on the Ohio 12th Grade Proficiency Test and skills used on the job by entry-level employees. Most of the science objectives were strictly of a science nature, such as demonstrating an understanding of the impact of natural phenomena on the Earth’s geological formations over short and long time spans, and had little, if any, direct application in a business setting. However, four of the 18 objectives do have a business application and these are the following: (a) formulate an experimental design to test a given hypothesis, (b) evaluate the scientific validity used in persuasive conversations, (c) analyze the results of changing the components in a simple system, and (d) predict the effect of a change on a process or procedure. These four objectives formed the basis of the next four questions. Questions 11-14 asked the participants to state the frequency, from at least once a week (the most frequent) to never (the least frequent), of the use of each of the applicable objectives by the person in the position the respondent listed for question 10.

It is important to note that each of the four learning outcomes selected from the list of 18 Proficiency Test outcomes requires critical thinking. The first, formulating an experimental design to test a hypothesis, is included specifically or generally in the CT
definitions of several researchers. That a question exists that requires evidence to support what is believed to be true fits part of the CT definition of Watson and Glaser (1980). Paul (1992) supports this outcome as an example of CT when he suggests that CT includes the ability to “formulate, analyze, and assess the problem or question at issue” (p. 11). Ennis (1985) suggests CT includes “formulating hypotheses, questions, alternatives, and plans for experiments (p. 45). Lastly, SCANS (Department of Labor, 1991) supports this outcome as part of CT by including specifying goals and constraints, generating alternatives, evaluating and choosing the best alternative as part of the decision making CT attribute.

The second Proficiency Test outcome used in this study’s survey, evaluating the scientific validity used in persuasive conversations, also involves CT. Watson and Glaser (1980) believe CT includes knowledge of the nature of valid inferences, abstractions, and generalizations in which the weight or accuracy of different kinds of evidence are logically determined. The ability to analyze inferences, reasoning, and lines of thought and implications and consequences that follow is a CT application according to Paul (1992). Deciding what to believe is in the realm of CT (Ennis, 1985). The CT attribute, decision making (Department of Labor, 1991), also applies to this second outcome since decision making includes evaluating and choosing the best alternative.

The third proficiency Test outcome used in this study, analyzing the results of changing the components in a simple system, requires the use of CT. Analyzing the results of change corresponds with acceptance of the need for evidence in supporting what is asserted to be true (Watson and Glaser, 1980). CT also includes “the ability to formulate, analyze, and assess implications and consequences” (p. 11) that follow the
gathering of evidence and data (Paul, 1992). The SCANS CT attribute, reasoning (Department of Labor, 1991), applies to this outcome when discovering “a rule or principle underlying the relationship between two or more objects and applies it in solving a problem” (p. xviii). In this case, the relationship is cause and effect.

Finally, the fourth Proficiency Test outcome used in this study, predicting the effect of a change on a process or procedure, also requires CT. The ability to formulate assumptions was suggested as in the domain of CT by Paul, (1992). The creative activity, formulating a hypothesis, is covered in the definition of CT by Ennis (1985). Generating new ideas and imagining new possibilities is a part of the SCANS critical thinking attribute, creative thinking (Department of Labor, 1991).

The four Proficiency Test outcomes used as the basis for questions 14 through 21 in the survey form the link in this study between the critical thinking required on the 12th Grade Proficiency Test and critical thinking required on the job. That each of these outcomes requires CT is clearly established in the preceding four paragraphs. Therefore, students who successfully complete test questions related to these four outcomes and employees who carry out job assignments using these four outcomes are demonstrating critical-thinking ability.

The final four questions (15-18) were almost identical with questions 11-14. However, the participant was asked to respond by identifying a percentage range of all employees who carry out the four objectives at least once a month. The purpose of these questions was again to seek correlation, if any, between the four applicable science objectives and the frequency of their use among all the employees in the sample companies.
The survey was piloted with five individuals representative of the target population. The objective was to refine the instrument so that all questions were clear and unambiguous and the time required for completion was less than five minutes. Testers were given the goals of the study and encouraged to offer suggestions for improvement.

3.3.2 Ohio 12th Grade Proficiency Test

One version of the Ohio 12th Grade Proficiency Test, specifically the 50 question Science Section, was chosen for an analysis of the critical thinking required to answer the questions. This test purports to measure what a graduating high school senior is expected to know before entering the workplace or moving on to higher education. It has been established in the literature that critical thinking ability is a skill necessary, or at least highly desirable, in graduates. A research hypothesis of this study suggests that critical thinking is required for success on this test. The author of the test, the Ohio Department of Education, maintains each version is comparable to any other. That is, each version is of similar validity and reliability.

Since the SCANS report has been so nationally influential in the workplace skills movement and since SCANS includes a description of critical thinking, the five critical thinking attributes of the SCANS report are a logical choice to use as a standard for analysis. Using the five SCANS critical thinking attributes, each of the 50 questions in the Science section was examined to determine which attribute(s) were required to successfully complete the question.
The procedure used for evaluating the 50 questions involved the following. The descriptions of the five SCANS CT attributes were carefully examined. Then each of the 50 science questions was analyzed to determine what information or skill was needed to successfully answer the question. The information or skill required was compared to the SCANS CT attributes to determine which one(s), if any, were necessary for success.

3.4 Data Collection Procedures

3.4.1 Employer Questionnaire

Copies of surveys along with a cover letter were sent to all 500 businesses in the sample. In order to increase the response rate, a second mailing was sent to those in the sample who did not respond to the first mailing.

3.4.2 Ohio 12th Grade Proficiency Test

This writer analyzed the science section of one version of the 12th Grade Proficiency Test for the use of critical thinking by test takers. The SCANS five attributes of critical thinking were used as a standard for comparison.
3.5 Data Analysis Procedures

3.5.1 Data Coding

**Employer survey**

The responses from the employer survey were converted into numerical scores and entered into the computer. Each of the 500 surveys was assigned an identification number from 001-500 and this same number was also assigned to the respondent when the survey was returned. During the second mailing, the nonrespondents to the first mailing were sent a second survey with a number identical to their first. Some respondents made their survey number unreadable and these were assigned a unique number slightly above 500, such as 501, 502.

**Ohio 12th grade proficiency test.**

The analysis of the 12th grade test was done by hand so no data coding was done.

3.5.2 Inferential Analysis

**Pearson correlation coefficient**

Pearson correlation coefficient was used to identify correlation between responses. The alpha level was $p \leq .05$.

**Multiple linear regression analysis**

Stepwise multiple linear regression analysis was conducted to identify significant ($p \leq .05$) predictors. In order to reduce possible loss of variance due to dichotomizing a
variable, selected variables were entered as independent continuous variables using so-called dummy variables (Kerlinger & Pedhauzer, 1973). Survey respondents either belonged in a category, such as a Northeast Ohio location, and assigned a “1” or they did not belong and were assigned a “0”. Variables treated in this manner included business location, type of business, and size of business.
CHAPTER 4

RESULTS

This chapter consists of five sections. The first section includes a descriptive analysis starting with information about survey respondents and proceeding through issues relating to the new workplace and critical thinking. See Appendix B for a complete listing of respondents’ answers to survey questions. Section two includes a discussion of significant Pearson correlation coefficients between critical thinking variables and business factors. Section three presents the results of multiple regression analyses. Section four includes an analysis of the critical thinking required on the Science Section of the Ohio 12th Grade Proficiency Test. The final section presents the results of the tests of the hypotheses of the study and a summary of findings.

4.1 Employer Survey

Of the 500 businesses that received the survey, a total of 187 (37.4%) completed surveys were returned. The first mailing was conducted in August, 2000 and produced 84 returned surveys. The second mailing occurred in February 2001 and resulted in 103 additional surveys.
4.2 Respondent Demographics

Table 19 presents information about the respondents by type of business, general location, and size. No effort was made to obtain a stratified sample by type, location, or size of business. As a result, Table 19 provides an interesting analysis of the current State of Ohio businesses in the three categories. The respondents identified themselves on the survey as manufacturing, service, retail, or other and also provided a general indication of their size by marking the number of employees in five categories. The business location was determined by dividing the State of Ohio into five regions and using the mailing addresses to identify the region in which each business was located. Although admittedly arbitrary, the formulation of the regions follows logical groupings of counties in the State of Ohio. Some cities and towns could be considered in different regions depending on who decides the boundaries of each region. However, such differences are thought to have a minor impact on the overall accuracy of the picture of business in Ohio. It should be noted that respondents often chose to not answer particular questions. This results in totals less than 187.
Table 19

*Demographics of Survey Respondents (N = 187)*

<table>
<thead>
<tr>
<th>Business Type</th>
<th>Location</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>49.2</td>
<td>37.1</td>
</tr>
<tr>
<td>Service</td>
<td>20.3</td>
<td>15.0</td>
</tr>
<tr>
<td>Retail</td>
<td>11.8</td>
<td>17.7</td>
</tr>
<tr>
<td>Other</td>
<td>18.7</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Listed by percentage of the total number of respondents. Other = wholesalers, distributors, construction, design, and advertising. Size refers to the number of employees.

Table 19 illustrates several facts concerning Ohio business. Manufacturing remains the dominant business type in Ohio despite the well-publicized loss of manufacturing jobs over the last two decades. The service category makes up a distant second. The literature suggests service is the high growth area of the new economy, that is, the area in which the most job growth will take place. The survey results measure the status in 2001 only, so it is not possible to conclude the direction, growth or decline, that each business type is taking, but service companies have a long way to go to overtake manufacturing in the total number of workplaces. What is not surprising is the fact that the results indicate that 89.8% of the respondents employ less than 50 people. This is
consistent with other reports suggesting the majority of businesses are small businesses. The number of large businesses is surprisingly small, none in the 251-500 employee range and only one with more than 500 employees. A possible reason for the small number of large companies is that the sample was drawn from only companies advertising in the Yellow Pages. At least some large Ohio companies do not advertise in the Yellow Pages. It is not known what effect the omission of larger companies, which do not advertise in the Yellow pages, might have had on the results. This may be a limitation of this study.

Of the 500 businesses in the sample, 313 or 62.6% did not respond. Using a table of random numbers, 30 nonrespondents were chosen for comparison to those responding to the survey. Table 20 compares the survey participants to the sample of nonrespondents as to type of business, business location, and number of employees.

Table 20

Comparison of Respondents to Nonrespondents by Business Type, Location, and Size

<table>
<thead>
<tr>
<th>Category</th>
<th>Respondents</th>
<th>Nonrespondents</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>percent</td>
<td>n</td>
</tr>
<tr>
<td>Type of business</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td>92</td>
<td>49.2</td>
<td>11</td>
</tr>
<tr>
<td>Service</td>
<td>38</td>
<td>20.3</td>
<td>10</td>
</tr>
<tr>
<td>Retail</td>
<td>22</td>
<td>11.8</td>
<td>6</td>
</tr>
<tr>
<td>Other</td>
<td>35</td>
<td>18.7</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 20 (continued)

<table>
<thead>
<tr>
<th>Location of business</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast Ohio</td>
<td>69</td>
<td>36.9</td>
<td>14</td>
<td>46.6</td>
<td>-0.026</td>
</tr>
<tr>
<td>Northwest Ohio</td>
<td>28</td>
<td>15.0</td>
<td>4</td>
<td>15.0</td>
<td>0.08</td>
</tr>
<tr>
<td>Central Ohio</td>
<td>33</td>
<td>17.6</td>
<td>4</td>
<td>15.0</td>
<td>0.46</td>
</tr>
<tr>
<td>Southeast Ohio</td>
<td>12</td>
<td>6.4</td>
<td>1</td>
<td>1.9</td>
<td>1.40</td>
</tr>
<tr>
<td>Southwest Ohio</td>
<td>44</td>
<td>23.5</td>
<td>7</td>
<td>24.6</td>
<td>-0.25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size of business by number of employees</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;50</td>
<td>168</td>
<td>89.7</td>
<td>24</td>
<td>80.0</td>
<td>0.08</td>
</tr>
<tr>
<td>51-100</td>
<td>14</td>
<td>7.5</td>
<td>3</td>
<td>10.0</td>
<td>-0.43</td>
</tr>
<tr>
<td>101-250</td>
<td>4</td>
<td>2.1</td>
<td>1</td>
<td>3.3</td>
<td>-0.18</td>
</tr>
<tr>
<td>251-500</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>&gt;500</td>
<td>1</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Note. Percentages may not total 100% due to rounding. \( z = \) \( z \) score obtained by computing the difference between two percentages for uncorrelated data.

Table 20 indicates consistent results comparing the respondents with the nonrespondents. Some differences should be expected between the two groups, but the general trends, such as region in which the most businesses are located, should be unchanged. This was the case. Testing the difference between the two percentages for uncorrelated data (Downie and Heath, 1970) in each group in Table 20 indicated no significant difference between respondents and nonrespondents in the three categories. This means that the respondents, although making up only about 1/3 of the sample, are
representative of the sample as a whole in these three categories. This gives confidence that the remaining responses of the respondents are also representative of the sample.

4.3 Skill Levels and Critical Thinking

The foundation of most of the rhetoric in the literature that is critical of the school’s preparation of students is that a gap exists between the job requirements of employers and what students as entry-level employees can deliver. Table 21 presents results on this issue.

Table 21

<table>
<thead>
<tr>
<th>Skill Statement</th>
<th>n</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELE lack basic reading and writing skills</td>
<td>32</td>
<td>17.1</td>
</tr>
<tr>
<td>The lack of work ethic is a greater problem than deficient academic skills</td>
<td>133</td>
<td>71.1</td>
</tr>
<tr>
<td>The skill level of our new hires is adequate</td>
<td>45</td>
<td>24.1</td>
</tr>
<tr>
<td>The required skill level of our ELE has been rising</td>
<td>32</td>
<td>17.1</td>
</tr>
</tbody>
</table>

Note. ELE = entry-level employees. n = number of positive responses. Percent = percent positive responses of all 187 respondents.

Table 21 summarizes some very important information. First, only 32, or 17.1%, of respondents indicate their new hires lack basic reading and writing skills. This seems to be in direct contradiction to much of the information presented previously that suggests
that students entering the workforce lack these basic skills. Are employers not requiring reading and writing on the job? The literature suggests the opposite is true. For Ohio employers, the data suggests the lack of basic reading and writing skills is not a major issue.

The lack of work ethic in employees does, however, appear to be a major issue. The data in this study agrees with several others that list the lack of work ethic as an important issue. Work ethic was not defined on the survey other than saying “punctuality and good attitude” in parentheses. The participants were allowed to interpret the term as they chose.

Only about one quarter of the respondents expressed satisfaction with the skill level of their applicants. Admittedly, this is a small percentage and the study did not go deeper to locate the basis for participants overall dissatisfaction. Further investigation is needed to determine what skills are lacking in their new hires.

Lastly, the data suggests only a small number, about one in six, of respondents view the skill level required of entry-level employees as rising. This is completely in contradiction to the great body of research cited in Chapter 2 that suggests the new, global economy requires more highly skilled workers.

One of the major points brought forth in Chapter 2 was that companies were, and are, adopting a new management style, one that gives more decision-making powers to employees and one that has less layers of management. The Survey asked two questions designed to discern the frequency of the existence of these workplaces. The questions were somewhat redundant in an effort to seek consistency among the respondents and
each response was written to be as attractive a choice as the other. A summary of the responses can be found in Appendix B. The results are presented in Table 22.

Table 22

*Management Styles used in the Workplace*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>n</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Traditional management style</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management makes decisions</td>
<td>158</td>
<td>84.5</td>
</tr>
<tr>
<td>Employees follow procedures, no problem solving</td>
<td>101</td>
<td>54.0</td>
</tr>
<tr>
<td>n = 259</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>New management style</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employees make decisions</td>
<td>27</td>
<td>14.4</td>
</tr>
<tr>
<td>Employees problem solve</td>
<td>81</td>
<td>43.3</td>
</tr>
<tr>
<td>n = 108</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* $n =$ number of respondents indicating this choice.

Table 22 indicates most survey participants are operating under the traditional management style. Once again this contradicts much of the literature, particularly the SCANS (Department of Education, 1991, 1992) reports, which state that it was an economic necessity to change from traditional to the new management style. Are the respondents lagging behind the trend or is the trend towards the new management style overstated? Likely, the trend was overstated. The data indicates that in a clear majority
of participant’s companies, management makes the decisions. However, only a slight majority indicate their managers do the problem solving and employees follow procedures. Apparently, many participants encourage employees to solve many of their own problems. Still, most companies’ managers do the problem solving, a characteristic of traditionally managed companies.

The ability to think critically has been established as an important and desirable skill. Table 23 gives the level of critical thinking used on the job.

Table 23

<table>
<thead>
<tr>
<th>Level</th>
<th>n</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>27</td>
<td>14.4</td>
</tr>
<tr>
<td>Moderate</td>
<td>92</td>
<td>49.2</td>
</tr>
<tr>
<td>Low</td>
<td>67</td>
<td>35.8</td>
</tr>
</tbody>
</table>

Note. High = critical thinking applied over totally new situations. Moderate = critical thinking applied over a narrow range of reoccurring situations. Low = no critical thinking applied.

Table 23 indicates few entry-level employees are practicing high levels of critical thinking. Most employees think critically over a narrow range of recurring situations. This is far different from employing thinking skills over new situations necessary at the highest level. Good training can allow an individual to function well at the moderate level. Over a third of respondents indicate their entry-level employees seldom need to
think critically at all. When the moderate and low levels are taken together, 85.0% of respondent’s entry-level employees are required to function only at moderate to low levels of critical thinking ability. Yet once again, this seems in contradiction with the literature, much of which maintains all or most employees must function at high levels of critical thinking ability.

4.4 Significant Correlations

The size of a business was significantly correlated with several variables related to critical thinking issues. Table 24 shows these correlations.

Table 24

*Significant Correlations Between Size of Business and Skill Levels and Critical Thinking*

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>( r )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q8 Testing for critical thinking part of prehire procedures</td>
<td>186</td>
<td>- .15</td>
<td>.043</td>
</tr>
<tr>
<td>Q10 Solving problems on the job</td>
<td>182</td>
<td>- .17</td>
<td>.019</td>
</tr>
<tr>
<td>Q11 Level of critical thinking used on the job</td>
<td>186</td>
<td>- .19</td>
<td>.010</td>
</tr>
</tbody>
</table>

Note. \( p \leq .05 \).

Q2 1 = less than 50 employees, 2 = 51-100, 3 = 101-250, 4 = 251-500, 5 = more than 500 employees

Q8 No = 1, Yes = 0.
Table 24 (continued)

Q10 Employees solve problems = 1, 
employees follow procedure, do not solve problems = 0. 

Q11 High level of CT = 3, moderate level of CT = 2, low level of CT = 1.

From Table 24 the negative correlations suggest that the smaller the business, the 
significantly less likely the business tests for critical thinking in prehire procedures \( (r = - .15, p = .043) \), and the more likely entry-level employees are encouraged to solve their 
own problems \( (r = -.17, p = .019) \). Also, the smaller the company, the significantly more 
likely high levels of critical thinking are required of entry-level employees \( (r = -.19, p = .010) \). This does seem logical. The smaller the business, the less division of labor and 
the more jobs each employee must fill. Larger companies would have more narrowly 
defined positions. Even though smaller companies require more critical thinking, it 
appears employers do not realize the importance of critical thinking since these employers 
do not indicate they test for critical thinking ability as part of their hiring process. It is 
possible some companies, such as the one described in Appendix A, use other means than 
a formal test to measure CT.

Despite the great volume of literature reporting a skills gap, some employers in 
the sample (24.1%, see Table 21) state they are satisfied with the skill level of their newly 
hired employees. There is significant correlation with those reporting satisfaction with 
skills of new hires and three other variables. These are presented in Table 25.
Table 25

*Significant Correlations Between Satisfaction with Skill Levels of New Hires and Variables Related to Skill Issues and Number of Applicants*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Q6 Correlations with satisfaction of skill levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n$</td>
</tr>
<tr>
<td>Q3 Applicant rejections</td>
<td>169</td>
</tr>
<tr>
<td>Q4 Most applicants lack basic skills</td>
<td>184</td>
</tr>
<tr>
<td>Q5 Lack of work ethic a greater problem than basic skills</td>
<td>184</td>
</tr>
<tr>
<td>Q7 Skill level of entry-level employees increasing</td>
<td>184</td>
</tr>
</tbody>
</table>

*Note.* $p \leq .05$.

Q6 1 = skill level is adequate, 0 = respondent did not indicate skill level is adequate

Q3 1 = no applicant rejections for each opening, 2 = 1-4 rejections, 3 = 5-9 rejections, 4 = 10-19 rejections, 5 = more than 20 rejections.

Q4 1 = applicants lack basic skills, 0 = did not indicate applicants lack basic skills.

Q5 1 = lack of work ethic a greater problem than basic skills, 0 = respondent did not indicate lack of work ethic a greater problem than basic skills.

Q7 1 = The required skill level of entry-level employees increasing, 0 = respondent did not indicate required skill level of entry-level employees in increasing.

Table 25 suggests the more satisfied an employer is with the skill level of new hires, the significantly (1) less applicants are rejected per new hire ($r = -.16, p = .040$), (2) less dissatisfaction the employer has with poor work ethic ($r = -.61, p = .000$), (3) less the employer feels applicants lack basic skills ($r = -.16, p = .029$) and less the employer
believes entry-level skill levels are increasing (r = -.19, p = .008). These data seem quite logical. It might be expected that less applicants are rejected, work ethic issues are less of a problem, the basic skills issue is less important, and the required skill level is not rising for those employers satisfied with the skill level of their new hires. However, this data might be interpreted another way: The less satisfied an employer is with skill levels, the more applicants are rejected, the work ethic issues are more problematic, the lack of basic skills is more important, and the required skill level of employees is rising.

Only a minority of employers in the sample, about one in six, stated that the skill levels of their entry-level workers are increasing. However, there are major significant correlations between stating that skill levels of entry-level workers are rising and all of the variables related to greater use of critical thinking required on the job. These correlations are shown in Table 26.
Table 26

Significant Correlations Between Employers Stating Entry-level Skills are Rising and Variables Related to Critical Thinking Required on the Proficiency Test

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlations with Rising Entry-level Skills</th>
<th>Q7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>r</td>
</tr>
<tr>
<td>Q11 Level of CT used on the job</td>
<td>183</td>
<td>.17</td>
</tr>
<tr>
<td>Q14 ELE formulate an experimental design to test</td>
<td>175</td>
<td>.28</td>
</tr>
<tr>
<td>a hypothesis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q15 ELE evaluate the scientific validity of data used in persuasive</td>
<td>175</td>
<td>.23</td>
</tr>
<tr>
<td>communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q16 ELE analyze the results of changing a component in a simple system</td>
<td>174</td>
<td>.22</td>
</tr>
<tr>
<td>Q17 ELE predict the effect of change on a process or procedure</td>
<td>174</td>
<td>.28</td>
</tr>
<tr>
<td>Q18 All employees formulate an experiment to test a hypothesis</td>
<td>179</td>
<td>.34</td>
</tr>
<tr>
<td>Q19 All employees evaluate the scientific validity of data used in</td>
<td>178</td>
<td>.28</td>
</tr>
<tr>
<td>persuasive communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q20 All employees analyze the results of changing a component in a</td>
<td>177</td>
<td>.21</td>
</tr>
<tr>
<td>simple system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q21 All employees predict the effect of a change on a process or</td>
<td>179</td>
<td>.28</td>
</tr>
<tr>
<td>procedure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 26 (continued)

**Note.** ELE = entry-level employees. p ≤ .05.

Q7 Required skill level of ELE is increasing = 1, required skill level of ELE is not increasing = 0.

Q11 High level of CT = 3, moderate level of CT = 2, low level of CT = 1.

Q14 A = 3, B = 2, C = 1, D = 0. Higher numbers indicate greater frequency.

Q15 through Q17 A = 4, B = 3, C = 2, D = 1, E = 0. Higher numbers indicate greater frequency.

Q18 through Q21 A = 0, B = 1, C = 2, D = 3, E = 4, F = 5. Higher numbers indicate greater frequency.

The positive correlations in Table 26 indicate that the ability to think critically is an important job skill for those employers who perceive that their entry-level employee skills are rising. It is important to note that not just some of the four skills were significantly correlated, but all four were significant for both entry-level and all employees. Although in this study the number of companies whose entry-level employee skills are rising is not near the level cited by some researchers, these companies do require high level and frequent use of critical thinking ability.

The literature emphasized the importance of the high performance workplace operating under the new management style. There were two survey questions designed to measure frequency of these workplaces among the sample businesses. There was a significant (p = .003) and positive (r = .22) correlation between respondents choosing “new management” responses for both questions. This correlation is presented in Table 27.
Table 27

**Significant Correlations between the New Management Characteristic of Employee Decision Making and Employee Problem Solving and Providing Advanced Training**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlations with Employee Decision Making (New Management Style)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
</tr>
<tr>
<td>Q9</td>
<td></td>
</tr>
<tr>
<td>Q10</td>
<td>181</td>
</tr>
<tr>
<td>Q12</td>
<td>183</td>
</tr>
</tbody>
</table>

**Note.** ELE = entry-level employees. p ≤ .05.

Q9 Management based decisions = 0, Employee based decisions = 1.

Q10 Employees follow procedures, management solves problems = 0, ELE think on their own, devise their own solutions = 1.

Q12 The company does not provide advanced training = 0, company provides training to advance ELE = 1.

If the questions are valid, then there should be consistency in the responses. Table 27 indicates such consistency. Respondents indicating their companies expect their entry-level people to make most of their own decisions, a new management characteristic, also want their entry-level employees to solve their own problems, also a new management characteristic. This is important, but because 41.2% chose the “new management” response for question 9 and 15.5% chose the “new management” response for question...
10, a determination of the frequency of companies operating under the new management style remains uncertain.

Table 27 also indicates a negative correlation ($r = -.17, p = .025$) between companies expecting entry-level employees to make their own decisions and companies providing training for advancement. This means that companies expecting decision making ability in their entry-level employees are less likely to provide training for advancement.

Since the literature is very clear that high performance workplaces operating under the new management style require higher levels of critical thinking, we would expect to find positive, significant correlations between “new management” responses on questions 6 and 7 and the frequent use of high levels of critical thinking on the job. With two exceptions, this was not the case. Question 10, employers preferring entry-level workers to solve their own problems, showed significant, positive correlation with the highest level of on-the-job critical thinking. However, only one significant correlation was found with the four skills using critical thinking from the 12th Grade Proficiency Test. These results are shown in Table 28.
Table 28

*Significant Correlations Between New Management Style and Variables Related to Critical Thinking*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Correlations with New Management Style</th>
<th>n</th>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q11</td>
<td>High levels of critical thinking used on the job</td>
<td>181</td>
<td>0.45</td>
<td>0.000</td>
</tr>
<tr>
<td>Q17</td>
<td>ELE predict the effect of change on a process or procedure</td>
<td>172</td>
<td>0.16</td>
<td>0.034</td>
</tr>
</tbody>
</table>

**Note.** High levels of critical thinking = critical thinking applied over totally new situations.

ELE = entry-level employees. $p \leq 0.05$. 

Q10 Traditional management style = 0, new management style = 1

Q11 High level of CT = 3, moderate level of CT = 2, low level of CT = 1.

Q17 A = 4, B = 3, C = 2, D = 1, E = 0. Higher numbers indicate greater frequency.

That no significant correlations with critical thinking variables were found with Question 9 and only two with Question 10, is not consistent with the bulk of the literature that predicted rising critical thinking needs as companies changed over to new management styles in high performance workplaces. However, the correlation between Question 10 and high levels of critical thinking used on the job does support the prediction. This indicates partial, but not overwhelming support for the rising critical-thinking needs predicted in the literature.
As reported previously in Chapter 4, only a small number of sample employers (14.4%) indicated their entry-level employees were required to use high levels of critical thinking. There were several significant correlations between the use of high levels of critical thinking and the variables related to critical-thinking skills used on the 12th Grade Proficiency Test. This data is presented in Table 29.

Table 29

*Significant Correlations Between High Levels of Critical Thinking Used on the Job and Variables Related to Critical Thinking Required on the Proficiency Test*

<table>
<thead>
<tr>
<th>Variables</th>
<th>$n$</th>
<th>$r$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q14 ELE formulate an experimental design to test a hypothesis</td>
<td>177</td>
<td>.27</td>
<td>.000</td>
</tr>
<tr>
<td>Q16 ELE analyze the results of changing a component in a simple system</td>
<td>176</td>
<td>.21</td>
<td>.006</td>
</tr>
<tr>
<td>Q17 ELE predict the effect of change on a process or procedure</td>
<td>176</td>
<td>.25</td>
<td>.001</td>
</tr>
<tr>
<td>Q18 All employees formulate an experiment to test a hypothesis</td>
<td>181</td>
<td>.28</td>
<td>.000</td>
</tr>
<tr>
<td>Q19 All employees evaluate the scientific validity of data used in persuasive communication</td>
<td>180</td>
<td>.26</td>
<td>.000</td>
</tr>
<tr>
<td>Q20 All employees analyze the results of changing a component in a simple system</td>
<td>179</td>
<td>.24</td>
<td>.001</td>
</tr>
</tbody>
</table>
Table 29 indicates that three of four skills used on the Science Section of the Proficiency Test that have application in a business setting are used by entry-level employees in those sample companies that require high levels of critical thinking in their entry-level employees. All four skills are used by high numbers of all employees. This means that at least some of the questions students face on the Proficiency Test requires skills that are actually used on the job with some businesses.

Correlation analysis revealed significant interrelation between questions 14 through 21 involving the four identified skills for entry-level and all employees. The significance was .000 or very close to .000 between questions. Respondents, who stated frequent use by entry-level and all employees of one of the four identified proficiency test skills, very likely also indicated frequent use of each of the other three skills. This consistency should be expected if all four proficiency skills are closely related to higher skill requirements in employees.
4.5 Multiple Regression Analysis for Predicting Business Characteristics

Survey data was analyzed by multiple regression to search for predictors of business size, location by region, and type of business. Several areas of significance were found, the first relating to the size of the business and this is shown in Table 30.

Table 30

*Multiple Regression of Critical Thinking Factors Predicting Size of Business (Q2)*

<table>
<thead>
<tr>
<th>Multiple R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>.19</td>
<td>.04</td>
<td>.03</td>
<td>.51</td>
</tr>
</tbody>
</table>

**Analysis of Variance**

<table>
<thead>
<tr>
<th></th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>1.46</td>
<td>1</td>
<td>1.46</td>
<td>5.56</td>
<td>.020</td>
</tr>
<tr>
<td>Residual</td>
<td>40.18</td>
<td>153</td>
<td>.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>41.64</td>
<td>154</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Coefficients**

<table>
<thead>
<tr>
<th></th>
<th>Beta</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q11 Depth of CT used on the job (less)</td>
<td>-.19</td>
<td>-2.48</td>
<td>.014</td>
</tr>
<tr>
<td>Q8 Pre-hire test of CT used</td>
<td>-.17</td>
<td>-2.22</td>
<td>.028</td>
</tr>
</tbody>
</table>

Note. CT = critical thinking. \( p \leq .05 \).
Table 30 (continued)

Q2  1 = less than 50 employees, 2 = 51-100, 3 = 101-250, 4 = 251-500, 5 = more than 500 employees.

Q11 High level of CT = 3, moderate level of CT = 2, low level of CT = 1.

Q8  Pre-hire test of CT used = 0, no test for CT in prehires = 1.

The data represented in Table 30 can be translated into a standard regression equation as shown here: $Q2 = (-0.19)Q11 + (-0.17)Q8$. This suggests that smaller companies are less likely to test their pre-hires for critical thinking and are more likely to require higher levels of critical thinking in their entry-level workers. Just missing the .05 level of significance was Question Six ($p = .051$). Including Question Six results in the interpretation that the less employees a business has, the more satisfied the business is with the skill level of new hires. This seems somewhat contradictory. One possible explanation for requiring higher levels of critical thinking is that smaller companies have less division of labor, that is, each employee is required to carryout more tasks than in larger companies. Larger businesses have the characteristic of more positions so that an employee can be more specialized. If smaller employers require employees to fill more roles, more skills associated with the ability to think critically are needed. With this emphasis on greater critical-thinking ability used in smaller businesses, it might be expected that employers would test applicants for critical thinking, but the data suggests otherwise. However, employers may use other means than what is considered typical when evaluating CT ability in new-hires. The VP of Operations for the company interviewed (See Appendix A) uses unusual methods of testing CT.
It might not be expected that the region of the state in which a business is located would significantly relate to critical thinking factors. However, two variables were identified as predicting the location of a business in one of the five geographic regions used in this study. Businesses in Northeast Ohio more frequently required entry-level employees to evaluate the scientific validity of data used in persuasive communication and less likely to require entry-level employees to use high levels of critical thinking. This is shown in Table 31. Businesses in Northwest Ohio, however, less frequently required entry-level employees to evaluate the scientific validity of data used in persuasive communication and this is shown in Table 32.
Table 31

*Multiple Regression of Critical Thinking Factors Predicting Location of Business in NE Ohio (n = 69)*

<table>
<thead>
<tr>
<th>Multiple R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.26</td>
<td>.07</td>
<td>.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis of Variance

<table>
<thead>
<tr>
<th></th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>2.44</td>
<td>2</td>
<td>1.22</td>
<td>5.53</td>
<td>.005</td>
</tr>
<tr>
<td>Residual</td>
<td>33.59</td>
<td>152</td>
<td>.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>36.03</td>
<td>154</td>
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</tbody>
</table>

Coefficients

<table>
<thead>
<tr>
<th></th>
<th>Beta</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q11 Depth of CT used on the job (less)</td>
<td>-.19</td>
<td>-2.44</td>
<td>.016</td>
</tr>
<tr>
<td>Q15 Evaluate the scientific validity of data (more)</td>
<td>.19</td>
<td>-2.44</td>
<td>.016</td>
</tr>
</tbody>
</table>

Note. CT = critical thinking. NE = Northeast. p ≤ .05.

Northeast = 1, other types = 0

Q11 High level of CT = 3, moderate level of CT = 2, low level of CT = 1.

Q15 A = 4, B = 3, C = 2, D = 1, E = 0. Higher numbers indicate greater frequency.
Table 32

*Multiple Regression of Critical Thinking Factors Predicting Location of Business in NW Ohio (n = 28)*

<table>
<thead>
<tr>
<th></th>
<th>Multiple R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.19</td>
<td>.04</td>
<td>.03</td>
<td>.36</td>
</tr>
</tbody>
</table>

Analysis of Variance

<table>
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<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>.79</td>
<td>1</td>
<td>.79</td>
<td>6.03</td>
<td>.015</td>
</tr>
<tr>
<td>Residual</td>
<td>20.17</td>
<td>153</td>
<td>.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>20.96</td>
<td>154</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Coefficients

<table>
<thead>
<tr>
<th></th>
<th>Beta</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q15 Evaluate</td>
<td>-.19</td>
<td>-2.46</td>
<td>.015</td>
</tr>
<tr>
<td>scientific validity of data (less)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. NW = northwest. p ≤ .05.

Northwest = 1, other types = 0

Q15 A = 4, B = 3, C = 2, D = 1, E = 0. Higher numbers indicate greater frequency.

The data represented in Table 31 can be translated into a standard regression equation as shown here: NE = (-.19)Q11 + (.19)Q15, and the data in Table 32 can be represented as the following: NW = (-.19)Q15. Evaluating the scientific validity of data used in persuasive communication was identified as a predictor for both Northwest and Northeast Ohio employers. However, for businesses in the Northeast, the beta was positive and for Northwest companies the beta was negative. This contradiction defies a
simple explanation. Perhaps more ELE may not use CT as often in NE Ohio. Also, evaluating validity of data could be a trait of start-up companies which might mean more start-ups are located in NE Ohio. NW Ohio is a dominant agricultural region and perhaps less CT is required as a result. More research is needed to study this issue.

The second factor identified, depth of critical thinking, is also puzzling. Northeast Ohio employers require less depth of critical thinking. Since more depth of critical thinking is significantly correlated with companies whose skill level is rising, some might conclude Northeast employers are experiencing skill levels that are not rising. However, this cannot be true otherwise multiple regression analysis would have identified survey question 7 (required skill levels are rising) as a predictor of location in the northeast. Because of the inconsistencies mentioned and the low number of factors identified, it appears little, if any, importance can be assigned to business location.

Multiple regression analysis also identified a small number of predictors for business type. The retail area showed three predictors, “other” was identified with two, and service was identified with one. Table 33 shows the data with retail as the dependent variable.
Table 33

*Multiple Regression of Critical Thinking Factors Predicting Retail Business (n = 22)*

<table>
<thead>
<tr>
<th>Multiple R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
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</tr>
</thead>
<tbody>
<tr>
<td>.33</td>
<td>.11</td>
<td>.09</td>
<td>.31</td>
</tr>
</tbody>
</table>

**Analysis of Variance**

<table>
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<tr>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>1.73</td>
<td>3</td>
<td>.58</td>
<td>6.17</td>
</tr>
<tr>
<td>Residual</td>
<td>14.17</td>
<td>151</td>
<td>.09</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>25.90</td>
<td>154</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Coefficients**

<table>
<thead>
<tr>
<th>Beta</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>.23</td>
<td>2.98</td>
<td>.003</td>
</tr>
<tr>
<td>.22</td>
<td>2.82</td>
<td>.006</td>
</tr>
<tr>
<td>-.19</td>
<td>-2.45</td>
<td>.015</td>
</tr>
</tbody>
</table>

Q2 Size of business

Q10 Employees solve their own problems

Q16 ELE frequently analyze changing. a component in a system

**Note.** ELE = entry-level employees. $p \leq .05$.

Retail = 1 other types = 0

Q2 1 = less than 50 employees, 2 = 51-100, 3 = 101-250, 4 = 251-500, 5 = more than 500 employees.

Q10 Traditional management characteristics = 0, new management characteristics = 1.

Q16 A = 4, B = 3, C = 2, D = 1, E = 0. Higher numbers indicate greater frequency.
The data represented in Table 33 can be translated into a standard regression equation as shown here: \( \text{RET} = (0.23)Q2 + (0.22)Q10 + (-0.19)Q16 \). This analysis identified (1) larger employers as more likely retail, (2) companies whose employees solve their own problems (new management) as more likely retail employers, and (3) businesses whose entry-level employees less frequently analyze the results of changing a component in a simple system is more likely in retail. The first predictor, size of business, may have resulted because some of the retail employers in the sample were part of a large, multi-store chain. The second and third predictors, critical thinking issues, are more difficult to explain. One possible explanation for the second is that the entry-level employee may be in a sales position in contact with the customer and going to the supervisor often with problems may result in lost sales. Employees may be forced to take care of customer problems immediately. Lastly, in retail establishments, entry-level employees are likely directed to follow procedures and are not encouraged to make changes on their own.

The category “other” (n = 35 or 18.7% of the sample) included businesses that do not fit neatly into manufacturing, service, and retail divisions. For example, employers who identified themselves as “other” include companies in wholesale distribution, construction/contracting, printing and design, advertising, farming, and one respondent who did not identify his or her business. Analysis identified two variables as predictors for “others”. This data is presented in Table 34.
Table 34

*Multiple Regression of Critical Thinking Factors Predicting “Other” Business (n = 35)*

<table>
<thead>
<tr>
<th>Multiple R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>.25</td>
<td>.06</td>
<td>.05</td>
<td>.38</td>
</tr>
</tbody>
</table>

_________________________________________________________________

**Analysis of Variance**

<table>
<thead>
<tr>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>1.43</td>
<td>2</td>
<td>.71</td>
<td>4.90</td>
</tr>
<tr>
<td>Residual</td>
<td>22.15</td>
<td>152</td>
<td>.15</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23.58</td>
<td>154</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Coefficients**

<table>
<thead>
<tr>
<th>Beta</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q15 ELE evaluate scientific validity of data</td>
<td>-.19</td>
<td>-2.24</td>
</tr>
<tr>
<td>Q20 Emp frequently analyze changing a component in sys.</td>
<td>.23</td>
<td>2.77</td>
</tr>
</tbody>
</table>

**Note.** Emp = all employees. ELE = entry-level employees. *p* \( \leq .05. \\

Table 34 (continued)

Q15 A = 4, B = 3, C = 2, D = 1, E = 0. Higher numbers indicate greater frequency.

Q20 A = 0, B = 1, C = 2, D = 3, E = 4, F = 5. Higher numbers indicate greater frequency.

The data represented in Table 34 can be translated into a standard regression equation as shown here: OTHER = (-.19)Q15 + (.23)Q20. A business whose employees are more likely to analyze the results of changing a component in a simple system and
whose entry-level employees less frequently evaluate the scientific validity of data used in persuasive communication are more likely in the “other” category. Almost all of the businesses in the “other” category are closely connected with their customers. The distributors must maintain a close customer relationship in order to stock and ship exactly what their customers need in their own businesses. The contractors must build exactly what was agreed upon in their contract with their customers. It follows logically that contractors, printers, and distributors often have sudden changes made by customers and they must quickly adapt to meet new needs. Employees able to analyze the results of changing a component in a simple system would be an asset to such businesses.

The second variable identified, less likelihood of entry-level employees frequently evaluating the scientific validity of data used in persuasive communication, can also be plausibly explained. Entry-level employees in construction, distribution, and printing are more likely to be in labor positions and less likely to be in direct contact with customers and their needs. If this is true, entry-level employees would be much less likely to evaluate scientific validity used in persuasive communication.

The same variable, less likelihood of entry-level employees frequently evaluating the scientific validity of data used in persuasive communication, was identified as a predictor of service companies. This means entry-level employees in service businesses more frequently evaluate the scientific validity of data used in persuasive communication than do entry-level employees in the businesses categorized by “other”. This is presented in Table 35.
Table 35

*Multiple Regression of Critical Thinking Factors Predicting Service Business (n = 38)*

<table>
<thead>
<tr>
<th>Multiple R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>.18</td>
<td>.03</td>
<td>.02</td>
<td>.39</td>
</tr>
</tbody>
</table>

**Analysis of Variance**

<table>
<thead>
<tr>
<th></th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>.72</td>
<td>1</td>
<td>.72</td>
<td>4.85</td>
<td>.029</td>
</tr>
<tr>
<td>Residual</td>
<td>22.85</td>
<td>153</td>
<td>.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23.57</td>
<td>154</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Coefficients**

<table>
<thead>
<tr>
<th>Q15 Evaluate scientific validity of data</th>
<th>Beta</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.18</td>
<td>2.20</td>
<td>.029</td>
</tr>
</tbody>
</table>

*Note.* $p < .05.$

Q15 A = 4, B = 3, C = 2, D = 1, E = 0. Higher numbers indicate greater frequency.

The data represented in Table 35 can be translated into a standard regression equation as shown here: $\text{SERVICE} = (.18)Q15$. One possible explanation is that many involved in service, such as plumbers and auto repair technicians, must often evaluate a wealth of information in order to fix something broken. Whether oral or written communication, the employee must discard that which is not valid and use what information is applicable and valid to solve the problem at hand.
4.6 Analysis of the Science Section of One Version of the Ohio 12th Grade Proficiency Test

The Science Section of one version of Ohio’s 12th Grade Proficiency Test was analyzed to identify critical thinking, if any, that was required to correctly answer the 50 questions. The entire Science Section is presented in Appendix G. The five critical thinking attributes described in the SCANS Report were used as the standard since SCANS has been the most influential work on what the schools should be doing to prepare young people for the workforce (See Table 4). The procedure used for evaluating the 50 questions involved the following. The descriptions of the six SCANS CT attributes were carefully examined. Then each of the 50 science questions was analyzed to determine what information or skill was needed to successfully answer the question. The information or skill required was compared to the SCANS CT attributes to determine which one(s), if any, were necessary for success. The results are presented in Appendix D in sequential order with the critical thinking attribute identified and the reasoning used to make the evaluation.

Almost all 50 questions in the Science Section require at least one of the SCANS critical thinking attributes. A summary of the critical thinking required on the 12th Grade Proficiency Test is presented in the Table 36.
Table 36

Critical Thinking Required on the Science Section of one version of the Ohio 12th Grade Proficiency Test (n = 50)

<table>
<thead>
<tr>
<th>Critical Thinking Attribute</th>
<th>Total Number of Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowing how to learn</td>
<td>1</td>
</tr>
<tr>
<td>Reasoning</td>
<td>24</td>
</tr>
<tr>
<td>Creative thinking</td>
<td>9</td>
</tr>
<tr>
<td>Decision making</td>
<td>15</td>
</tr>
<tr>
<td>Problem solving</td>
<td>0</td>
</tr>
<tr>
<td>Mental visualization</td>
<td>20</td>
</tr>
<tr>
<td>No critical thinking</td>
<td>4</td>
</tr>
</tbody>
</table>

Note. The number of questions in the table totals more than the 50 on the Science Section since a question may require more than one critical thinking attribute to answer.

A breakdown by this writer of the specific SCANS critical thinking attributes by question is presented in Table 37.
### Table 37

*SCANS critical thinking attributes required by test question*

<table>
<thead>
<tr>
<th>Question CT number</th>
<th>Knowing how to learn</th>
<th>Reasoning</th>
<th>Creative thinking</th>
<th>Decision making</th>
<th>Problem solving</th>
<th>Mental visualization</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>x</td>
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<td>x</td>
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<td>x</td>
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<td>x</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
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<tr>
<td>27</td>
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<td>x</td>
<td>x</td>
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<tr>
<td>29</td>
<td>x</td>
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<td>x</td>
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<tr>
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</table>
Forty-six, or 92%, of the fifty Science section questions requires at least one of the SCANS critical thinking abilities. Only four questions are of a simple recall nature. Those who are critical of proficiency testing based on the complaint that teachers are teaching to the test using factual information are incorrect. Those who drill facts into students in preparation for the 12th Grade Test are doing their students a disservice. It is obvious that students must be able to think critically if they are to be successful.
Most noticeable from Tables 36 and 37 is the total absence of problem-solving questions, yet this is one ability often cited as needed by employers. The SCANS report defines problem solving as recognizing that a problem exists, for example, that there is a discrepancy between what is and what should be, and identifies possible reasons for the discrepancy and devises and implements a plan of action to resolve it (Department of Education, 1992). None of the 50 questions presents a discrepancy of what is and what should be to Ohio students, at least in 2000. The Ohio Department of Education (2001) states “In assessing science content, more emphasis is placed on conceptual understanding and critical-thinking skills; less emphasis is placed on technical vocabulary and computation skills” (p. 262). There is no mention of problem solving specifically.

The most frequent critical-thinking ability required is reasoning. Twenty-four questions, or 48%, require the test taker to identify relationships and draw conclusions based upon the given information. The questions include life, earth, and physical science principles.

The second most frequent critical-thinking ability needed is mental visualization, required in 20, or 40%, of the Science Section. The test writers used graphs, tables, and illustrations extensively to present information and this requires the student to organize and process this information. Often other critical thinking abilities are needed to arrive at the correct answer, but first the information in tables and graphs must be processed.

Decision making is required on 15, or 30%, of the questions. The argument can be made that all 50 questions use the decision-making ability to choose the correct answer from the selections available or to decide what to write on the free response questions. However, this writer followed the strict SCANS description of decision making to
identify the nature of the question. Admittedly, this is a gray area and required much subjective analysis.

Only 9 questions, or 18%, required creative thinking on the part of the test taker. The key factor in the determination was if the student was asked to predict a new situation, idea, or possibility based on the information given. He or she must use their imagination to take a step beyond the data to arrive at a new possibility. For most, this is likely a difficult task.

The knowing how to learn ability was cited in only one, or 2%, of the fifty questions. As described by SCANS, this critical thinking ability is more applicable to a learning situation rather than an evaluative event such as taking the Proficiency Test. The student very rarely uses learning techniques, learning tools, and informal learning strategies in a test-taking atmosphere. As a result, this ability was not usually used.

4.7 Tests of Hypotheses

4.7.1 Hypothesis 1

There is a significant correlation between critical thinking used on the job and the size of the business. Hypothesis 1 accepted. Analysis of survey results indicates smaller businesses were significantly (p = .010) more likely to require higher levels of critical thinking from their entry-level employees than were larger businesses.
4.7.2 Hypothesis 2

There is a significant correlation between critical thinking used on the job and the type of business. 

Hypothesis 2 conditionally rejected. Analysis of survey results indicates almost no significant correlation between critical thinking used on the job and type of business. Two exceptions were illustrated in Tables 33 and 34.

4.7.3 Hypothesis 3

There is a significant correlation between critical thinking used on the job and the location of a business.

Hypothesis 3 conditionally rejected. Analysis of survey results indicates almost no significant correlation between critical thinking used on the job and location of business. Only two exceptions were found and these are shown in Tables 31 and 32.

4.7.4 Hypothesis 4

There is a significant correlation between critical thinking used on the job and the critical thinking required on the Science Section of the Ohio 12th Grade Proficiency Test. 

Hypothesis 4 conditionally accepted. Some respondents (17.1%) indicated rising skill levels. There is a significant correlation (See Table 26, all positive r values ranged from .17 to .34, p levels ranged from .000 to .004) between the critical thinking required on the four proficiency outcomes applicable to a business setting and the critical thinking required of both entry-level employees and all employees of these respondents.
4.7.5 Hypothesis 5

There is a significant relationship between those businesses exhibiting characteristics of the high performance workplace and increasing skill levels. **Hypothesis 5 rejected.** Analysis of data indicated no significance between businesses exhibiting characteristics of the high performance workplace and increasing skill levels.

4.7.6 Hypothesis 6

There is significant correlation between businesses exhibiting characteristics of the high performance workplace and employees demonstrating use of critical thinking at the highest level. **Hypothesis 6 accepted.** Analysis revealed significant correlation ($r = .45$, $p = .000$) between businesses exhibiting characteristics of the high performance workplace and employees demonstrating use of critical thinking at the highest level.

4.7.7 Hypothesis 7

There is a significant, positive correlation between businesses that require a high level of critical thinking from their employees and the more frequent use of the four proficiency outcomes applicable to a business setting.
Hypothesis 7 accepted. Analysis of Table 29 revealed significant, positive correlation (r values ranged from .21 to .28, p levels ranged from .000 to .006) between those employers requiring entry-level employees to use the highest level of CT, applying CT over totally new situations, and three of four of the proficiency outcomes for entry-level employees and all four of the proficiency outcomes for all employees.

4.8 Summary of Findings

The following is a list of the significant (p ≤ .05) findings from the analysis of the data gathered from Ohio businesses.

4.8.1 Workplace skills – skills gaps

1. The majority of respondents indicated continued use of traditional management methods.
2. Businesses who were satisfied with the skill levels of their new hires expressed less dissatisfaction with work ethic and lack of basic skills.
3. Only a small segment (17.1%) of the businesses sampled indicated dissatisfaction with the basic academic skill level of employees.
4. A large majority (71.1%) of the sample businesses in Ohio viewed a lack of work ethic of employees more important than a deficiency in academic skills.
5. Only a minority (17.1%) of sample employers reported that the skill level of entry-level employees is rising.
4.8.2 Critical thinking

1. About one third of businesses sampled required no critical thinking of their entry level employees.

2. Slightly less than two thirds of the sampled employers required moderate to high levels of critical thinking.

3. Small businesses were more likely to require high levels of critical thinking from their entry-level employees than larger businesses.

4. Businesses who reported rising skill levels in entry-level employees were requiring all of their employees to exhibit critical thinking similar to that required on four outcomes used on the Proficiency Test.

5. Businesses who indicated one new management characteristic required high levels of critical thinking of employees and required employees to more frequently predict the effect of a change on a simple system.

6. Sample businesses which required high levels of critical thinking in entry-level employees also required employees to achieve the four outcomes from the Proficiency Test.

7. Sample businesses located in Northeast Ohio more frequently required entry-level employees to evaluate the scientific validity of data used in persuasive communication.

8. Sample businesses located in Northeast Ohio less frequently required entry-level employees to use high levels of critical thinking.
9. Sample businesses located in Northwest Ohio less frequently required entry-level employees to evaluate the scientific validity of data used in persuasive communication.

10. Sample businesses who described themselves as “other” were requiring entry-level employees to more frequently evaluate the scientific validity of data used in persuasive communication.

4.8.3 Science Section Ohio 12th Grade Proficiency Test

1. Almost all of the questions (92%) on the science section of one version of the Ohio 12th Grade Proficiency Test required at least one of the SCANS critical thinking attributes to answer correctly.

2. The four outcomes from the science section of the Ohio 12th Grade Proficiency Test that have an application in a business setting were used on the job by employees.

3. One of the SCANS critical thinking attributes, problem solving, was not tested by the science section of the Ohio 12th Grade Proficiency Test.

4.8.4 Characteristics of sample respondents

1. Manufacturing was the most dominant type of business sampled.

3. The most common size for businesses sampled in Ohio was businesses employing less than 50 people.
3. Sample businesses who described their companies as retail (1) were more likely larger in number of employees, (2) more likely exhibited the new management characteristic of requiring employees to solve their own problems, and (3) less likely required entry-level employees to analyze the results of changing a component in a simple system.

4. Most businesses sampled were managed using traditional methods.
CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Chapter five has four purposes. The first is to present a summary of the study. The second purpose is to summarize the study’s findings, conclusions, and comparisons with previous studies. The third purpose is to answer the major research questions and the fourth purpose is to propose recommendations for practice and further research.

5.1 Summary

The major purpose of this study was to examine the workplace skills issue and how this issue impacts, or should impact, science education, the science education curriculum, and the proficiency tests. The focus of this study was the use of critical thinking, both on the job and on the Science Section of the Ohio 12th Grade Proficiency Test.

The study consists of two parts, first, an employer survey was conducted of a sample of Ohio businesses on the subject of workforce skills and critical thinking used on
the job and, secondly, an examination was undertaken of the critical thinking required to answer questions on the Science Section of one version of the Ohio 12th Grade Proficiency Test. A total of 500 Ohio businesses were randomly selected to receive the survey and the first mailing occurred in August 2000. Nonrespondents to the first mailing were sent a second copy of the survey in February 2001. A total of 187 businesses responded to the survey. The 50 question Science Section of the Ohio 12th Grade Proficiency Test was analyzed using five attributes associated with the ability to think critically.

Data was examined using correlation analysis and multiple linear regression. Correlation analysis was used to identify significant relationships between critical thinking variables and variables related to business characteristics. Multiple linear regression identified predictors of membership in specific business categories.

5.2 Findings, Conclusions, and Comparison with Previous Studies

5.2.1 Adoption of the High Performance Workplace

Closely related to rising employee skill levels, the degree of adoption of the high performance workplace utilizing the new management style appears overstated. Carnevale and Carnevale (1994), Carnevale et al (1988,) and SCANS (Department of Education 1991, 1992) particularly were frequent proponents of the high performance workplace and predicted widespread adoption by business. This study found only 14.4% of respondents identifying the new management characteristic of employee decision making as part of their company’s policy. Problem solving by employees rather than by
management, also a new management/high performance workplace characteristic, was identified as company policy by 43.3% of respondents. The only figures found on this issue in the literature were Carnevale & Porro’s (1994) statement that as few as 5% and as many as 26% of private workplaces are attempting to install high performance workplaces. They seemed unable to arrive at a more definitive amount than the 5-26% range and this study also found difficulty in arriving at an estimate of high performance workplaces in Ohio.

Even though the numbers of high performance workplaces have not matched predictions of major studies, this study did find significant positive correlations between one characteristic of these workplaces and two variables related to critical thinking. It was found that respondents who encourage employees to solve their own problems, were significantly ($r = .45$, $p = .000$) more likely to require the highest level of critical thinking from their entry-level employees. It was also found that respondents who encourage employees to solve their own problems, were significantly ($r = .16$, $p = .034$) more likely to require entry-level employees to predict the effect of a change on a process or procedure at least once a week. Both of these correlations agree with the prediction of the two major papers on workplace skills, SCANS (Department of Education 1991, 1992) and the ASTD Report (Carnevale et al (1988)). However, that only two were found does not support the importance of the high performance workplace and the new management style. The data suggests the adoption of the high performance workplace and the new management style has not become as widespread as speculated by some researchers in the 90s. A future study should examine trends, if any, towards adoption of the high performance workplace and the new management style.
5.2.2 Employee Skills Gap

Much has been written about a skills gap between what an entry-level worker should know and can do compared to what the new hire actually knows and can do. This study found only 17.1% of respondents stating their entry-level employees lack basic academic skills such as reading and writing. This is a contradiction to Clark (1988), Gordon (1990), Jones (1996), Joyce & Voytek (1996), Ohio Department of Education & Ohio Business Roundtable (1998), Townley (1989), and Woodhead (1996) who stated employers frequently criticize the schools for failing to provide a fundamentally skilled entry-level employee for the new economy. This finding also disagrees with SCANS which estimates that less than half of all young adults have achieved reading and writing minimums; even fewer can handle the mathematics; and schools today only indirectly address listening and speaking skills (Department of Labor, 1991). This finding also contradicts the conclusions of the Ohio Skills Gap Initiative which concluded only 14% of Ohio graduating seniors have the skills for entry-level positions (Ohio Department of Education & Ohio Business Roundtable, 1998). The OSGI focused on academic skills that graduating seniors should know from their education. The inconsistencies in the Ohio Skills Gap Initiative were discussed in Chapter 2.

A large segment of respondents, 71.1%, feel the lack of work ethic among entry-level employees is more important than lack of basic skills. This is in agreement with the Sandia Report described in Perspectives on Education (1993) which concluded that over
80% of employers express concern over “skills”, but they generally mean a good work ethic and social skills. This finding also agrees with a survey of employee skills conducted of Dayton area employers in 1997 (Cited in Mansfield News Journal, August 28, 1999, p. A1). The top five skills were ones commonly included under the general term “work ethic”. Basic academic skills, including computer skills, were listed as the last five out of 13 skills. Wilhelm (1999) cites similar results in another study. Barone (2004) suggests schools are part of “Soft America” where coddling, the lack of competition, and the lack of accountability result in an abundance of incompetent eighteen year olds. He observed that as students enter “Hard America”, the exposure to competition and accountability in adult life causes a metamorphosis into competent adults by the time they are 30. This writer suggests the lack of work ethic in entry-level employees also results from the “Soft America” Barone describes. The apparent solution, at least according to Barone, is to “harden” the schools by increasing accountability.

This study found only 24.1% of survey participants responding that they are satisfied with the skill level of their entry-level employees. From this study it cannot be definitively determined what are the opinions of the other 75.9% who apparently are not satisfied with the skill level of their new hires. This would be an area worthy of further research.

Correlational analysis indicated a significant negative relationship between those who are satisfied with the skill levels of their entry-level employees and three variables. One variable concerns the number of applicants rejected per opening. The more satisfied the employer is with the skill level of new hires, the significantly less (r = -.16, p = .040) applicants are rejected per opening. It is logical to relate the number of application
rejections with the number of people who apply. The more applications submitted for an opening, the more rejections occur. Following this line of thought, employers satisfied with skill levels of new hires reject less applicants simply because less applicants apply. It is also reasonable to believe that the more desirable a position is, the more applications will be filed. If it is true that the more desirable a position is, the more the position may pay and the more skills are required, then employers satisfied with skill levels may be offering low skill, low wage positions. This last conclusion can only be speculated from the data and this area is worth further investigation.

A second variable related to satisfaction with skill level of new hires is a satisfaction also with basic academic skills. The more satisfied the employer is with the skill level of new hires, the significantly ($r = -.16, p = .029$) less likely the employer is to be dissatisfied with a lack of basic academic skills. This relationship is logical. However, the idea that any businesses exist which are satisfied with basic academic skills contradicts the main body of research on workplace skills such as Carnevale et al (1988), OSGI (Ohio Department of Education & Ohio Business Roundtable, 1998), and SCANS (Department of Labor, 1991, 1992).

The last variable related to satisfaction with skill level of new hires is a satisfaction with the work ethic of new hires. The more satisfied the employer is with the skill level of new hires, the significantly ($r = -.61, p = .000$) less likely the employer identified work ethic problems as a greater concern than low academic skills. Since these employers have no issue with the lack of basic skills, any work ethic problems should be very important. However, this does not seem to be the case. Recall lack of work ethic was identified as an issue with over 70% of respondents which means this group of
employers has to be a minority. The fact that they seem so satisfied with skill levels is in
agreement with Carnevale et al (1988), OSGI (Ohio Department of Education & Ohio

5.2.3 Skill Levels and Critical Thinking

Rising skill levels and critical thinking

One of the most important findings in this study relates to rising skill levels and
critical thinking used on the job. First, only 17.1% of respondents indicated the skill
levels required of their new hires have been rising. Carnevale et al (1988), Davis &
Roberts (1996) have predicted a rise in employee skill levels due to the demands of the
new, global economy. Baloun (1995), Clinton (1987), Kearns and Doyle (1988), and
Magnum (1996) also predicted higher skilled employees. That only one in six of the
respondents indicated rising skill level requirements is completely in disagreement with
the predictions of these researchers. However, this finding is in general agreement with
data from the Sandia Report. It said that first; only 5% of employers feel education and
skill requirements are increasing significantly. Secondly, only 15% of employers report
difficulty finding skilled workers. Shortages generally occur in chronically underpaid
areas (Perspectives on Education, 1993). The difference between the two camps is this:
the researchers predicting the need for higher skilled employees were speculating future
needs based on a changing economy while the other studies, including this one, measured
actual employee skill needs at the time of each study.
If the 5% figure in the Sandia report for 1993 is reliable and this study’s 17.1% value is correct, then there has been about a 300% increase in companies reporting increasing skill levels. However, the Sandia report was a national study while this study was restricted only to Ohio businesses. In addition, this study’s 17.1% figure applies only to the required skill levels of entry-level employees. Therefore, it is not likely a comparison is valid. Still, one of six companies reporting rising skill level requirements in entry-level workers is low, too low to agree with the majority of the great body of work (cited in Chapter 2) on workplace skills since 1985.

This study found several interesting and important relationships and correlations between companies indicating rising required skill levels in their entry-level employees and many variables related to critical thinking used on the job. The general finding was that most employers require low or modest levels of critical thinking by entry-level employees, but employers who say the required skill level of entry-level employees is rising are requiring high level and frequent use of critical thinking skills.

**Descriptive analysis**

First, the respondents indicated the overall use of higher critical thinking by entry-level employees was quite low. The respondents were faced with three choices; entry-level employees must (1) apply critical thinking over totally new situations, (2) apply critical thinking over a narrow range of reoccurring situations, or (3) follow proven, established procedures and are seldom called upon to think in a critical manner. The choices are listed in order of decreasing levels of critical thinking. Only 14.4% of respondents indicated their entry-level employees function at the highest level, 49.2% indicated entry-level employees must function at the middle level, and 35.8% indicated
entry-level employees seldom have to think critically. Taken together, 85.0% of respondents require no or modest amounts of critical thinking. However, looking at this data in another way, it can also be stated that 63.6% of respondents require modest or high levels of CT.

For clarification purpose, an example of an entry-level position requiring the middle level of critical thinking is presented. The raw materials in the manufacturing process carried out by the Wisconsin paper manufacturer described in Appendix A are 500 pound bales of used paper. After unloading, the employee must decide whether to accept or reject each bale. This kind of decision is a basic aspect of critical thinking described at length by Ennis (1985). The company provides training for the employee and has established criteria by which the employee will decide what to do, that is, to accept or reject each bale of recycled paper. The employee is thinking critically, but over a narrow range of reoccurring situations. The fact that the choices presented from which to choose are few and the situation of choosing occurs over and over, makes this job one requiring only a modest amount of critical thinking.

The executive interviewed at this paper plant would exhibit characteristics of high levels of critical thinking. His main task is to keep the plant operating within parameters that result in profitability. A multitude of different problems emerge frequently that must be addressed. If he is to be successful in his job, this manager must be a competent critical thinker at the highest level.

This finding that such a majority of sampled businesses (85.0%) require low or moderate levels (or 63% require moderate to high levels) of critical thinking by entry-level employees disagrees with major researchers. The ASTD report by Carnevale et al
(1988), Kearns & Doyle (1988), and SCANS (Department of Education, 1991, 1992) have all concluded expertise at thinking critically is of great importance by all employees.

5.2.4 Correlation Analyses

Several important and significant correlations were found between businesses who reported rising skill levels required of entry-level employees and variables related to critical thinking. There was a significant ($r = .17, p = .021$) relationship between sampled businesses who identified rising skill levels required of entry-level employees and the highest level of critical thinking used on the job. This means that businesses that identified that the required skill levels of their entry-level employees have been rising were significantly more likely to require the highest level of critical thinking from their entry-level employees. The highest level of the three presented to the respondents requires the ability to think critically over totally new situations.

This study found significant positive relationships between responses which state the required skill levels of entry-level employees has been rising and all four of the outcomes which use critical thinking found on the Proficiency Test for both categories of employees, entry-level and all employees (See Table 26). This means that respondents who stated the required skill levels of their entry-level employees have been rising were significantly ($r = .28, p = .000$) more likely to require entry-level employees to formulate an experimental design to test a hypothesis at least once a week. These employers were also significantly ($r = .34, p = .000$) more likely to require greater numbers of all employees to formulate an experimental design to test a hypothesis.
This study found a significant relationship between employer’s perceptions that the required skill levels of entry-level employees has been rising and requiring entry-level employees to evaluate the scientific validity of data used in persuasive communication at least once a day, a second critical thinking outcome from the Proficiency Test. Sampled businesses who stated the required skill levels of their entry-level employees have been rising were significantly ($r = .23, p = .002$) more likely to require entry-level employees to evaluate the scientific validity of data used in persuasive communication at least once a day. These employers were also significantly ($r = .28, p = .000$) more likely to require greater numbers of all employees to evaluate the scientific validity of data used in persuasive communication.

This study also found a significant relationship between employers’ perceptions that the required skill levels of entry-level employees have been rising and requiring entry-level employees to analyze the results of changing a component in a simple system at least once a day, the third learning outcome using critical thinking from the Proficiency Test. Respondents who stated “the required skill levels of their entry-level employees have been rising” were significantly ($r = .22, p = .004$) more likely to require entry-level employees to analyze the results of changing a component in a simple system at least once a day. These employees were also significantly ($r = .21, p = .004$) more likely to require greater numbers of all employees to analyze the results of changing a component in a simple system.

Finally, this study also found a significant relationship between employers’ perceptions that the required skill levels of entry-level employees have been rising and requiring entry-level employees to predict the effect of a change to a process or procedure
at least once a day, the fourth learning outcome using critical thinking from the Proficiency Test. Respondents who stated the “required skill levels of their entry-level employees have been rising” were significantly (r = .28, p = .000) more likely to require *entry-level* employees to predict the effect of a change to a process or procedure at least once a day. These employees were also significantly (r = .28, p = .000) more likely to require greater numbers of *all* employees to predict the effect of a change to a process or procedure.

This study also found significant correlations between companies requiring their employees to function at the highest level of critical thinking and all four learning outcomes using critical thinking by entry-level and all employees. For all eight correlations r = .21 to .28 and p < .010 (See Table 29). Companies which required employees to use the highest level of CT were significantly (r = .21 to .28, p < .010) more likely to require the most frequent use by entry-level and all employees of all four of the Proficiency Test outcomes which have an application to a business setting.

These significant positive correlations are important findings. The fact that high levels of critical thinking and frequent use of critical thinking are required of entry level employees in companies whose required skill levels are rising agrees with the main projections of Carnevale et al (1988), Davis & Miller, (1996), Davis (1995), Department of Labor (1991, 1992), Kearns and Doyle (1988), Marino (1995), Ohio Department of Education (1995), and Roberts (1996). Where the discrepancy exists is in projecting more businesses becoming high performance workplaces than actually exist in 2003, at least in Ohio.
The four learning outcomes requiring critical thinking, which were used by this study to measure frequency of the use of critical thinking on the job, are part of 18 learning outcomes used as a guide or standard to propose questions for the Science Section of the 12th Grade Proficiency Test. The correlations between these four outcomes and critical thinking used on the job mean that there is at least some general connection between the critical thinking required of employees in some companies and the critical thinking required of students taking the Ohio 12th Grade Proficiency Tests.

5.2.5 Multiple Regression Analyses

Multiple regression analysis identified only a small number of factors predicting the size, location, and type of Ohio business. Two factors were identified that predicted the size of companies and one factor identified that businesses were located in Northwest and Northeast Ohio. For type of business, three factors predicted retail establishments, two indicating “other” businesses, and one predicted service companies. For comparison, Table 38 presents respondent distribution by size, region, and business type.
Table 38

*Distribution of respondents by region, size, and business type (n = 187)*

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Northwest Ohio

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Southwest Ohio

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Southeast Ohio

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Note. Size = number of employees

Smaller businesses in the sample were significantly ($r = -.19$, $p = .014$) more likely to require the highest level of critical thinking from their entry-level employees and significantly ($r = -.17$, $p = .028$) less likely to consider critical-thinking ability as part of the formal selection process (See Table 30). As discussed in Chapter 4, the most likely explanation of small employers requiring the highest level of critical thinking is that the small employers often have employees perform multiple tasks. For example, one employee may be the organization’s bookkeeper, buyer, receiver, and tax advisor. Performing multiple tasks increases the likelihood that the entry-level employees will apply critical-thinking skills over totally new situations, this study’s definition of the highest level of critical thinking. That smaller employers test prehires less for critical thinking may indicate the employers are not aware of the importance of critical-thinking ability in their organization. Perhaps these employers would benefit if they tested their applicants for critical thinking. The company described in Appendix A requires both the
ability to perform multiple tasks by their entry-level employees and pre-employment screening for critical thinking.

Two factors predicting the location of a business were identified. Employers located in Northeast Ohio were significantly \( r = -.19, p = .016 \) less likely to require employees to think critically at the highest level and significantly \( r = .19, p = .016 \) more likely to require entry-level employees to frequently evaluate the scientific validity of data used in persuasive communications (See Table 31). Conversely, employers in Northwest Ohio were significantly \( r = -.19, p = .015 \) less likely to require entry-level employees to frequently evaluate the scientific validity of data used in persuasive communications (See Table 32). Since this study has found a significant relationship between businesses whose skills are rising and the highest level of critical thinking, it might suggest businesses in Northeast Ohio were more likely to note rising required skill levels. However, this cannot be concluded since multiple regression analysis did not link rising skill levels with Northeast Ohio companies. The finding that the frequency for entry-level employees to evaluate scientific validity of data is less for Northwest Ohio and more for businesses in Northeast Ohio is confounding. As suggested earlier, if evaluating scientific validity of data is a characteristic of start-up companies, then perhaps there are more start-ups in NE Ohio. This is, of course, pure speculation. Overall, the meaning of the multiple regression data predicting business location is uncertain.

Several factors predicting business type were identified. Retail businesses were significantly \( r = .23, p = .003 \) more likely to have a greater number of employees, more likely \( r = .22, p = .006 \) to require employees to solve their own problems and significantly \( r = -.19, p = .015 \) less likely to frequently require entry-level employees to
analyze the results of changing a component in a simple system (See Table 33). As discussed in chapter 4, retail employers in the sample may be more likely a branch of a regional or even national retail chain. The data in Table 39 indicates three of the eight Northeast Ohio retail respondents have more than 100 employees. No retail respondents in the four other regions employed more than 50. Most problems may result from direct sales contact with the customer. The employee may not have time to consult with management and must solve problems immediately.

Two variables predicted “other” businesses and only one predicted service companies. Sample businesses in the “other” category were significantly ($r = -.19$, $p = .026$) less likely to require entry-level employees to evaluate the scientific validity of data used in persuasive communication and significantly ($r = .23$, $p = .006$) more likely to require all employees to analyze the results of changing a component in a simple system. The “other” category includes many kinds of businesses in the sample (See Table 39 for distribution by size and region). Such variety causes analysis of the significance in this category to be difficult, if not impossible. Service companies were found to require entry-level employees more frequently to evaluate the scientific validity of data used in persuasive communication ($r = .18$, $p = .029$). Often service company employees operate away from their business and frequently face complicated problems requiring considerable expertise. Evaluating the scientific validity of data may be an important part of solving the problems they face.

No distinct patterns relating to business location or type of business were found using multiple regression analysis, but a significant relationship was found relating smaller business size to high levels of critical thinking used by employees. Since small
businesses do less prehire testing for critical thinking (see Table 24), this study concludes small business employers are not aware of the importance of critical thinking in their organizations or of ways to assess CT.

5.3 Answers to the Major Research Questions

1. Are there geographical differences in the critical-thinking requirements of business?

Multiple regression analysis indicated only a very few variables that predicted business location. Evaluating the scientific validity of data used in persuasive communication was identified as a predictor for both Northwest and Northeast Ohio employers. However, for businesses in the Northeast, the beta was positive and for Northwest companies the beta was negative. Further exploration is needed to determine the meaning and significance of these results.

2. Are there differences in critical-thinking required on the job by different types of businesses in Ohio?

Multiple regression and correlational analysis indicated only very few significant relationships between type of business and critical thinking required. Businesses whose entry-level employees less frequently analyzed the results of changing a component in a simple system were more likely retail. A business whose employees were more likely to analyze the results of changing a component in a simple system and whose entry-level
employees less frequently evaluated the scientific validity of data used in persuasive communication were more likely in the “other” category. The same variable, less likelihood of entry-level employees frequently evaluating the scientific validity of data used in persuasive communication, was identified as a predictor of service companies. Further exploration is needed to determine the meaning and significance of these results.

3. What is the depth of critical-thinking required in Ohio businesses?

Most of the businesses sampled (49.2%) required a modest level of critical thinking of their entry-level employees, applying critical thinking over a narrow range of reoccurring choices. Slightly more than a third (35.8%) required no critical thinking at all. Only 14.4% required entry-level employees to function at the highest levels of critical thinking, the employee must make frequent choices based on totally new situations. This data can suggest both low and high critical thinking requirements by entry-level employees depending on how the data is viewed. If the moderate and the no critical thinking percentages are combined, then it can be said that 85.0% of respondent entry-level employees are required to exhibit no more than a moderate level of critical thinking. However, if the high and moderate level percentages are combined, this suggests that 63.6% of respondent entry-level employees must function at least at a moderate level of critical thinking ability. Either way the data is chosen to be viewed, it is certain that the low number of employees required to function at the highest level is much less than predicted by proponents of the new economy described in Chapter 2.
4. What percent of Ohio businesses sampled are high-performance workplaces in?

High-performance workplaces make up a minority of all businesses in the sample. The two survey questions, each asking respondents to choose between two selections, one presenting a high-performance workplace characteristic, the other a traditional workplace characteristic, gave inconclusive results. For one of the questions, 14.4% selected the high-performance workplace choice and for the second, 43.3% selected the high-performance workplace choice. However, only 18 of the 187 respondents (9.6%) selected both high-performance workplace choices. The wording of these two questions was based on Carnevale’s (1988) comparison of today’s and tomorrow’s workplaces (traditional and high performance).

5. Is there a correlation between critical-thinking tasks needed on the Ohio 12th Grade Proficiency Test Science Section and those required on the job by Ohio entry-level employees?

A correlation was found, but only for some businesses. The four critical thinking tasks used in the survey were taken from the 18 learning outcomes for the Science Section of one version of the Ohio 12th Grade Proficiency Test. These four have application in a business setting. There was a significant positive correlation between
businesses whose entry-level employees’ skills have been rising (about 1 in 6 companies) and all four of the critical thinking tasks carried out by entry level employees.

6. Is there a correlation between critical-thinking tasks needed on the Ohio 12th Grade Proficiency Test Science Section and those required on the job by all Ohio employees?

A correlation was found, but again for only some businesses. There was a significant positive correlation between businesses whose entry-level employees’ skills have been rising (about 1 in 6 companies) and all four of the critical thinking tasks carried out by all employees.

7. What percent of Ohio businesses sampled test for critical-thinking ability during pre-employment screening?

Descriptive analysis indicated that only 21.4% of the sample businesses tested for critical thinking ability during pre-employment screening. There was no appreciable difference in testing for CT between types of businesses although manufacturers tested the least. This study did not assess employers’ awareness of assessment tools. Therefore, it is not known whether employers who do not test for critical thinking do not value critical thinking, are not aware of how to test for critical thinking, or employ some other means of testing for CT.
7. What proportion of Ohio businesses face an increase in the required skill level of their entry-level employees?

Only 17.1% of the sample indicated that the required skill level of their entry-level employees has been rising, about one in six businesses. This study did not attempt to discern characteristics about these companies. Multiple regression analysis did not find significance with respect to business size, location, or type of business.

5.4 Recommendations

1. This study has found that for about 20% of Ohio businesses sampled, critical-thinking ability is a very important quality in both entry-level and other employees. School curricula should reflect this by offering more opportunities to develop these skills. Keeping in mind the work of Sternberg and Martin (1988), laboratory exercises in which the student designs the experiment to test a hypothesis appears an excellent activity to help develop the ability to think critically. Also in agreement with Sternberg and Martin, critical-thinking exercises would be more beneficial if they were modeled after real-life issues.

2. This study supports many others identifying the lack of work ethic as a pernicious problem for the majority of Ohio employers. Educators must place greater emphasis on traits associated with work ethic such as punctuality, attention to detail, following directions, and finishing a job satisfactorily. Since many employers (such as the company described in Appendix A) require employees to function as part of a team, cooperative
learning projects as part of the science curricula would be particularly relevant and applicable.

3. This study found that the four learning outcomes applicable to a business setting that are included on the Ohio 12th Grade Proficiency Test and on the Ohio Graduation Test are skills actually used by employees on the job. Even more cooperation and perhaps partnerships between business and education can only improve the preparation of our graduates.

   It was noted that problem-solving questions were not part of the Science Section analyzed in this study. If SCANS is considered a standard of what students should know and be able to do, then problem solving questions should be a part of the Ohio Department of Education’s Science Section in the future.

5.5 Future Research

1. Only about 25% of respondents were satisfied with the skill levels of their entry-level employees. This study did not specifically address the source of the dissatisfaction with skill levels. Previous research has focused on the skills that are lacking, but most are several years old (1985-1999) and do not focus on Ohio employers. The sources of dissatisfaction should be identified. There may be a difference in the skill level of high school versus college graduates. A future study should consider differing questions to determine whether the respondent considers the skill levels as different between the two groups.
2. Previous research has predicted an increase in high-performance workplaces using the new management style. This study did not confirm these predictions, but was not designed to identify any trends. Further research is needed to determine how the frequency of high-performance workplaces in Ohio is changing. A management scale should be developed that would rank the category by degree. The comparison of new and traditional management characteristics (Table 2) could be used to construct such a scale.

3. This study concluded that employees of smaller companies in Ohio more frequently use critical-thinking skills and a possible explanation was presented. It would be more useful if the explanation was supported by research.

4. Only 1 in 6 businesses in Ohio indicated their entry-level employee skill levels needs were increasing. More research is needed to determine what types of businesses make up this group.

5. It would be useful to know if there is a correlation between success on proficiency tests and success on the job as an entry-level employee.

6. Much has been written about a skill deficiency in our high school graduates. Better designed research is needed to determine the exact nature of this skills gap, if any exists. Good research in this area is lacking. Future surveys should more precisely define the terms “basic skills” and “work ethic” since this study’s definitions of these terms was somewhat vague and open to respondent interpretation. This writer suggests descriptive research as a first step. A researcher might identify 15 to 20 entry level employees recently hired in four or five businesses representing the general business types described in this study. Case studies could be compiled comparing the match, or lack of a match, between specific skills needed by these companies and the skills possessed by the 15-20
entry-level employees and the success they have in meeting job expectations. The data from the case studies would serve as a guide to the types of questions that should be asked and the kinds of data that should be gathered that would lead to a well designed, quantitative study that would definitively and finally settle the skills issue.

7. This study suggests that some employers are satisfied with the skill levels of their applicants. It was speculated by this writer that these employers might be offering only low skill/low wage positions. Research is needed to determine if this is true.
REFERENCES


Agne, R.M., & Blick, D.J. (1972). A comparison of earth science classes taught by using original data in a research-approach technique versus classes taught by conventional approaches not using such data. *Journal of Research in Science Teaching, 9*(1), 83-89.


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APPENDIX A

INTERVIEW WITH A MANAGER OF A HIGH PERFORMANCE WORKPLACE USING THE NEW MANAGEMENT STYLE
An interview was conducted with the Vice President for Operations of a paper manufacturer located in Northern Wisconsin on August 6, 1997. This company was cited by Paul (1993) as an example of how a high performance workplace using the new management style has been put into practice. This company is an example of a manufacturer in the 51-100 employee range. This writer wrote the Vice President of Operations and followed with a phone call to set up the interview.

The plant had two previous owners and was operated under the traditional management style with a union workforce. The last owner had financial difficulties and the plant was closed and sat idle for several years before the present owners acquired the property and resumed production under the new management style.

The interviewer is the writer and is “Bill” in the transcript and the interviewee identified as VP. The last part of the interview experienced poor audio quality due to background noise and could not be transcribed.

BILL: I’d like to know first of all about the company – what are the products produced here, what are the markets, the number of employees?

VP: (Our company) is a six-year old company, basically, and we were a one-person for several years while we accumulated investors who brought together other investors, venture capitalists, people who wanted to dabble in this business. There are 16 investors in the company; purchased the mill in 1993. We started up that year, started with about 45 employees and we currently have 74 employees – that’s total corporate employees.
We make a variety of tissue and paper products in jumbo roll form. We do not make consumer goods. We make jumbo rolls for sale to other companies who make consumer goods such as toilet paper, napkins. Our typical customer is a converting operation that makes the rolls into napkins. We use all recycled paper in our manufacturing process. We buy a variety of different recycled materials and process it to make the large rolls. We wrap it up, store it, and ship it.

BILL: How far away are your main customers?

VP: A lot of our customer base is located right here in the state of Wisconsin and most of that is in the Fox River Valley. This is the lion’s share of our business and this gives us a competitive advantage having them so close. This is an advantage of having them 200 miles away instead of 400 miles away. And the advantage is that it allows us to get our work force to our customers.

BILL: I want to ask you about your management style. I was just reading about it last week. Your management style is a little different than what is normally used in industry. The article I read refers to your company giving 83 interviews when it started up in 1993.

VP: We conducted 83 interviews – that was for the selection process. We ended up with about 45 employees to start – so that’s a fairly accurate number. We use a pretty unique and rigorous interview process. We have a work system here that is not a fit to everybody. I’ll talk about the selection process. We have a team-based multi-skilled
work system. We’re non-traditional and non-union. Previous operation here was union and was union for years. This non-union application is understood by the workforce here. They don’t feel a need for it and my job is to make sure they don’t feel a need for it. So we have a multi-skilled, team-based work system where we have four operating teams that work four days on, four days off, 12 hour shifts, and those four teams rotate through those four days on and four days off. And each of those teams is comprised of 11 people and those 11 people have multiple skills, such that that team manages the receipt of raw materials, moving the raw materials from the truck to storage, the preparation of raw materials to make tissue, and the actual manufacturing of the tissue. Each team is responsible for the whole process. Each person has two-skill areas so that there is overlapping of the skills on each team. There are seven skill areas. On average, the 11 people have the ability to master two skills. We pay a base pay and then we pay extra for each of the two skills they acquire. So the expectation is that people have multiple skills and they use those skills. The work system was designed with three premises: 1) multi skills – all of us have multi-skills. A tree falls of your house, for example. You may have the skills and the tools to fix the damage or you may call someone in from the outside. The same thing happens here. If an employee has the skill, he is expected and encouraged to use it. This is different from our culture. The concept we use here is that you shouldn’t have to be asked.

We expect people to do a multiple number of things. We expect people not to be asked or to be told to do something – that we just know its right to do. And that differs from the traditional management style. The old management style is that people don’t know what they are doing and that I, as manager, have to tell them what to do. We truly
hire people to be members of the (Company) team and treat them, call them, (Company) team. And truly expect them to be owners of the business and to make decisions on very important issues. We have people who make decisions every 20 minutes that make or lose the company money and they strive to meet the target. We set a realistic target and they strive to mix different types of fibers to make the end product to the satisfaction of the customer. That’s the bottom line and they know it. We practice open-book management; employees know how much money we make at the end of each month. They know our costs, they know our fiber costs, they know all the production numbers so the principle I operate from, that we operate from, the more information they have, the better decisions they make. That’s where the critical thinking is. Our workforce needs to act like they are owners of the company and make those important decisions and feel comfortable making those decisions. Sometimes the decisions aren’t as good as you’d like. On the flip side, we have the long term vision that building that knowledge base and truly empowering people we get good results and that’s clearly what we’ve done here. We’ve improved our capacity 70% and we’ve cut our costs a million a month. I hate to use the word “empowered” because it’s been overused but that’s what we’ve done.

BILL: In psychology there is such a phrase as rising to the level of expectation – in other words the more one expects of someone, the more will be delivered.

VP: Yup! Yes, we expect more and that’s why the hiring process is so critical. We hire people who are good thinkers and good team members because we expect a lot out of people. They work hard both physically and mentally. We expect a lot and they do rise
to expectations – no question about that. And they do this because of self-satisfaction. They see the results. They know that if I do this, I will see this as a consequence. So, multi-skilled is one of the attributes; the second is operate/maintain. The best operator is the best maintainer. And vise versa – the best maintenance person is the one who can best operate that machine. We combine these two jobs together and don’t have the traditional division line between the two. People who just do one thing and don’t do anything else, that causes wide walls and high walls and there’s no cooperation back and forth. That doesn’t occur here. It’s interesting because we have been culturalized and because of the rest of the culture that we live in it’s a constant drain trying to break down the bars and standards that separate jobs. People leave here and their next door neighbor asks them, well, what do you do? Our employees say we’re team members. And the neighbor says well, what’s that? Our culture kind of burdens us by putting us in a box with a narrow label. This is the box, this is what I’m responsible for, this is what I do. We don’t have boxes here. Well, we kind of have dotted line boxes. We have a very flexible workforce. People who can do each others jobs and that’s the power. The other power to our workforce is that we are 74 people and we really don’t want to grow although we could probably develop to 85 or 90. If we need to get much bigger than this, we’ll just buy another plant. We’ll stop the growth at 85 or 90 and go somewhere else. The belief is that this number is the ideal organizational size.

BILL: To get larger, you would get too impersonal, do you think?
VP: Yes, we would get too many employees who would be too mechanical. People can get disjointed with too large an organization and they would just come in, work, and check out. We don’t want that. We want people to be lively, vivacious. If you get too big, you loose that. I read “Thriving on Chaos” in 1992 and it said that the ideal organizational size was 50 to 75 people and I believe that. No question about it.

And our third aspect of the under pinning of the work system is rotation. There is rotation within the team to maintain the skills you have, rotation from team to team, operational team to maintenance team, and just the rotation of four days on and four days off. People have opportunities here to walk in the other person’s shoes. We can’t have any glass houses. I know the other persons job, the difficult parts of it. So we don’t have a lot of second guessing.

BILL: So, then you look for people who are multiply skilled. The article talks about giving oral and written presentations, along with the interview.

VP: This is our environment here. We were very conscious when we started the work system here to try to develop a work system emphasizing analysis and synthesis of the functioning team. We hire people through an assessment process. We start off by giving them a comprehensive mathematics test. We want to see where they fall out. Our average employee has a 8th to 12th grade math and reading level. We just hire people with less than that even if they had an 8th grade level, they’d have to be strong in other areas to be considered. So that’s the challenge. What we find, what I find, is that people with two and even four year degrees can’t pass the test. It’s just devastating to see that. To give an
8th grade reading test and not have a college graduate pass it is sad. And this reading test isn’t anything difficult. So we provide a reading and math test and the rest is a group assessment. We typically do these on Saturdays so that it doesn’t interrupt a person’s normal work week. We start at 8:00 a.m. and finish around 2:30 or 3:00. And so it’s a good five or six hours of work. The critique of the process has been very positive and people walk away feeling good, even if they don’t get offered a job. We feel that this is because they believe they been dealt with fairly, that they learned something about themselves and that they learned something about other people. It’s a very fulfilling experience, although it causes a fair amount of anxiety because we ask them to do things they might never have done before. As applications come in at the front desk, they come to me. I do the first assessment. I look at the applications. I evaluate the completeness of the application, the spelling, and the general answering of the questions. The applications go here or go here – they go in the acceptance pile or the rejection pile and the rejection pile gets a lot bigger and thicker than the other pile. After two to three months, we conduct an assessment on a Saturday. That’s the history of the last several years. We’ll take the 20 to 25 people who have made it to that point and I’ll do one more cull. I go through them, do reference checking, ask people around here if they know them, what kind of person they are, and that gets the number down to about 10 or 12 that will be invited to participate in one of the assessments. We give them the math and reading test and we give them the team assessment. They do some team and some individual things. What we’re really looking for is the ability of the individual to work on a team and it’s not important that they get the right answer and most of them don’t. What’s important is that they can function as a team member; that they can work to build on other’s ideas, that
they can draw ideas out of others. So as they are going through this exercise, the first one is called stuck truck. A truck is stuck under an overpass, what would you do to unstick it? While the group is working on this problem, there are two assessors who are evaluating their progress, their abilities, looking for that interaction, the ability to communicate, the ability to build on others ideas as I mentioned before.

Poor audio quality made the remainder of the interview unrecoverable.
APPENDIX B

SURVEY DATA
Total businesses contacted – **500**

Responses from first mailing – **84** (16.8%)

Responses from second mailing – **103** (24.8%) of 416 business not responding to first mailing

Total responses – **187** (37.4%)

**Breakdown by business category**

- **Manufacturing** – 92 49.2%
- **Service** – 38 20.3%
- **Retail** – 22 11.8%
- **Other*** – 35 18.7%

*Others identify themselves as distributors, wholesalers, construction firms, design firms, farming, and advertising.

**Breakdown by business location**

- **Northeastern Ohio** – 69 36.9%
- **Northwestern Ohio** – 28 15.0%
- **Central Ohio** – 33 17.6%
- **Southwestern Ohio** – 44 23.5%
- **Southeastern Ohio** – 12 6.4%

One respondent did not specify location
Breakdown by size of business

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Question 4a: Responses (yes or positive) to the statement “The majority of our entry level job applicants lack basic reading and writing skills”.

32 (17.1%)

Question 4b: Responses (yes or positive) to the statement “The lack of work ethic (punctuality, good attitude) is a greater problem than deficient academic skills”.

133 (71.7%)

Question 4c: Positive responses to the statement “The skill level of our new hires is adequate for our needs”.

45 (24.1%)
Question 4d: Positive responses to the statement “The required skill level of our entry level employees has been rising”.

32 (17.1%)

Question 5: Responses to the question “Is testing for critical thinking a part of your companies prehire procedures for entry level positions requiring a high school diploma?”

Yes 40 (21.4%)
No 146 (76.3%)
No response 1 (0.5%)

Question 6: Inquiry concerning the respondent’s work environment.

A. “We hire good people, but they do need direction and our management team has the role of providing this direction”.

158 (83.4%)

B. “We expect our people to make most of their own decisions even though some decisions turn out to cost us money”.

27 (14.5%)
No Response 2 (1.1%)

Question 7: Inquiring regarding respondent’s hiring preferences.

A. “We prefer our entry-level people to think on their own, to devise their own solutions to problems that arise. Employees should consult management only when they cannot solve the problem on their own.”
B. “Our management/engineers have already done the thinking and we have excellent processes in place. We want entry level people who can follow established, proven procedures”.

101 (54.0%)

No response 5 (2.7%)

Question 8: Inquiry concerning the frequency of thinking critically on the job.

A. “Our entry level employees must apply critical thinking skill over totally new situations.”

27 (13.4%)

B. “Our entry-level employees must apply critical thinking over a narrow range of reoccurring situations.”

92 (46.7%)

C. “Our entry-level employees must follow established, proven procedures and are seldom called upon to think in a critical manner.”

67 (35.8%)

No response 1 (0.5%)
Question 9: Responses to the prevalence of training to advance entry-level employees

“Does your company provide training to aid entry-level workers move into advanced positions?”
A. Yes
   132 (70.6%)

B. No
   53 (28.3%)

No response  2 (1.1%)

Respondents were next asked in question 10 to consider an applicant who demonstrates superior critical thinking ability and were asked to list the specific position into which this new hire would be placed.

Responses varied greatly according to the type of business.

The following four questions ask the respondent to identify how often the new hire listed in question ten would perform four specific outcomes listed on the science segment of the Ohio Twelfth Grade Proficiency Test.

Question 11: “How frequently does the person in the position you listed in question 10 ‘formulate an experiment to test an hypothesis’?”
A. About once a week
   56 (29.9%)

B. About once a month
   35 (18.7%)
C. Once or twice a year
   27 (14.4%)

D. Never
   60 (32.2%)
No response  9 (4.8%)

Question 12: “How often does the person in the position you listed in question 10 ‘evaluate the scientific validity of data used in persuasive communication such as evaluating an advertising claim’?"

A. About once a day
   23 (12.3%)

B. About once a week
   22 (11.8%)

C. About once a month
   16 (8.6%)

D. Once or twice a year
   24 (12.8%)

E. Never
   93 (49.7%)

No response  9 (4.8%)
Question 13: “How often does the person you listed in question 10 ‘analyze the results of changing a component in a simple system’ on the job?”

A. About once a day
   45 (24.1%)

B. About once a week
   37 (19.8%)

C. About once a month
   29 (15.5%)

D. Once or twice a year
   24 (12.8%)

E. Never
   42 (22.5%)

No response 10 (5.3%)

Question 14: “How often is the person you listed in question 10 asked to predict a change on a process or procedure?”

A. About once a day
   41 (21.9%)
B. About once a week
   27 (14.4%)

C. About once a month
   38 (20.3%)

D. Once or twice a year
   32 (17.1%)

E. Never
   39 (20.9%)

No response  10  (5.3%)

Question 15: “Please estimate the percent of all your employees who are expected to formulate an experiment to test a hypothesis at least once a month.”

A. None
   59 (31.6%)

B. From 1-10%
   58 (31.0%)

C. From 11-25%
   16 (8.6%)
D. From 26-50%
14 (7.5%)

E. From 51-75%
17 (9.1%)

F. From 76-100%
18 (9.6%)

No response 5 (2.7%)

Question 16: “Please estimate the percent of all your employees who evaluate the scientific validity of data used in persuasive communication such as evaluating an advertising claim?”

A. None
60 (32.1%)

A. From 1-10%
63 (33.7%)

B. From 11-25%
26 (13.9%)
C. From 26-50%
   9 (4.8%)

D. From 51-75%
   12 (6.4%)

E. From 76-100%
   11 (5.6%)

No response  6 (3.2%)

Question 17: “Estimate the percent of all employees who analyze the results of changing a component in a simple system.”

A. None
   25 (13.4%)

B. From 1-10%
   65 (34.8%)

C. From 11-25%
   31 (16.6%)

D. From 26-50%
   19 (10.2%)

264
E. From 51-75%  
17 (9.1%)  

F. From 76-100%  
23 (12.3%)  

No response 7 (3.7%)  

Question 18: “Estimate the percent of all your employees who are asked to predict the effect of a change on a process or procedure.”  

A. None  
27 (14.4%)  

B. From 1-10%  
72 (38.5%)  

C. From 11-25%  
31 (16.6%)  

D. From 26-50%  
12 (6.4%)  

E. From 51-75%  
16 (8.6%)  

F. From 76-100%  
24 (12.8%)  

No response 5 (2.7%)
Nonrespondents

Of the 500 surveys, 313, or 62.6%, did not respond. Using a table of random numbers, 30 nonrespondents were chosen for comparison to those responding.

Nonrespondent breakdown by business location

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<td>24.6%</td>
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Nonrespondent breakdown by business category

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APPENDIX C

SURVEY
Employer Survey of Critical Thinking

1. What is the nature of your company’s business? Check one.
   A. ____ Manufacturing
   B. ____ Service
   C. ____ Retail
   D. ____ Other ______________________

2. How many employees are in your company? Check one.
   A. ____ 50 or less
   B. ____ 51-100
   C. ____ 101-250
   D. ____ 251-500
   E. ____ more than 500

3. For each new entry level employee hired into your company in the last year, how many applicants were rejected? Check one.
   A. ____ More than 20
   B. ____ From 10-19
   C. ____ From 5-9
   D. ____ From 1-4
   E. ____ We have openings that are unfilled.

4. Check any of the following statements that are true for your company’s entry-level positions requiring a high school diploma.

   A. ____ The majority of our entry-level applicants lack basic reading and writing skills.
   B. ____ The lack of work ethic (punctuality, good attitude) is a greater problem than deficient academic skills (reading, writing, and basic math).
   C. ____ The job skill level of our new hires is adequate for our needs.
   D. ____ The required skill level of our entry-level employees has been increasing
5. Is testing for critical thinking ability a part of your company’s pre-hire procedures for entry-level positions requiring a high school diploma?  **Check one.**

A. ___ Yes
B. ___ No

6. Which of the following statement best typifies the work environment at your facility?

A. ___ We hire good people, but they do need direction and our management team has the role of providing this direction.
B. ___ We expect our people to make most of their own decisions even though some decisions turn out to cost us money.

7. Which of the following represents your hiring preferences?  **Check one.**

A. ___ We prefer our entry-level people to think on their own, to devise their own solutions to problems that arise. Employees should consult management only when they cannot solve the problem on their own.
B. ___ Our management/engineers have already the thinking and we have excellent processes in place. We want entry-level people who can follow established, proven procedures.

8. **Check one** of the following scenarios that best illustrates your employees normal work environment.

A. ___ Our entry-level employees must apply critical thinking skills over totally new situations.
B. ___ Our entry-level employees must apply critical thinking skills over a narrow range of reoccurring situations.
8. ___ Our entry-level employees must follow established, successful procedures and are seldom called upon to think in a critical manner.

9. Does your company provide training to aid entry-level workers to move into advanced positions?

___ A. Yes
___ B. No
10. A job applicant demonstrates an ability to think critically at a high level. If you could place this applicant in any entry-level position to best benefit your company, write in the space below the specific job in which you would place him/her.

In the future, all Ohio students must pass the Twelfth Grade Ohio Proficiency Test. The following 8 questions refer to specific outcomes from the Science Section of the Proficiency Test.

11. How frequently does the person you listed in question 10 “formulate an experimental design to test a hypothesis”?* Check one.

___ A. About once a week
___ B. About once a month
___ C. About once or twice a year
___ D. Never

12. How frequently does the person you listed in question 10 “evaluate the scientific validity of data used in persuasive communication such as evaluating an advertising claim”?*

___ A. About once a day
___ B. About once a week
___ C. About once a month
___ D. About once or twice a year
___ E. Never

13. How frequently does the person you listed in question 10 “analyze the results of changing a component in a simple system”* on the job?

___ A. About once a day
___ B. About once a week
___ C. About once a month
___ D. About once or twice a year
___ E. Never
14. How often does the person you listed in question 10 asked to predict the effect of a change on a process or procedures?

___ A. About once a day
___ B. About once a week
___ C. About once a month
___ D. About once or twice a year
___ E. Never

15. Please estimate the percent of all your employees who are expected to “formulate an experimental design to test a hypothesis”* at least once a month.

___ A. None
___ B. From 10-10%
___ C. From 11-25%
___ D. From 26-50%
___ E. From 51-75%
___ F. From 76-100%

16. Please estimate the percent of all your employees who are expected to “evaluate the scientific validity of data used in persuasive communication such as evaluating an advertising claim” at least once a month?*

___ A. None
___ B. From 10-10%
___ C. From 11-25%
___ D. From 26-50%
___ E. From 51-75%
___ F. From 76-100%
APPENDIX D

ANALYSIS OF ONE VERSION OF THE SCIENCE SECTION OF THE 12TH GRADE PROFICIENCY TEST FOR THE SCANS CRITICAL THINKING ATTRIBUTES.
Question 1
Students must be able to identify the pattern in the sequence of steps in Koch’s procedure, then draw a conclusion to predict the final step. This is an example of reasoning because the student must use logic to draw a conclusion based on available information.

Question 2
This question clearly requires creative thinking by the test taker. The student is presented with a segment of Koch’s work, isolating bacteria and injecting the bacteria into an animal to see if they caused a disease. The four responses are not directly related to Koch’s work. The test taker must make a connection between seemingly unrelated ideas that reveal a new possibility.

Question 3
The student is presented with a table of freezing temperatures of four solutions in four concentrations. The four graphs that follow represent four possibilities for the freezing temperature of cesium chloride. Choosing the correct graph requires the test taker to demonstrate knowledge of a common scientific learning tool, graphing. This is an example of both the knowing how to learn and mental visualization critical thinking abilities.

Question 4
The student is asked to predict the freezing temperature of a concentration of cesium chloride that is not on the table. Here again mental visualization is required to interpret the data table, then the test taker must spot the pattern in the
data and draw a logical conclusion as to the freezing temperature of the concentration not in the table. This requires reasoning ability.

**Question 5**

This question requires no critical thinking ability. The correct answer is determined by recalling a common lab safety procedure.

**Question 6**

A table of data concerning five planets and five facts about each of the five planets is presented. The test taker must identify the most closely related of four facts of the planets to the period of revolution. First, the student must process the data in the table, then decide and choose which alternative best fits the relationship desired. To do this, the student must demonstrate the critical thinking abilities reasoning and decision making.

**Question 7**

To choose which of the planets has the shortest day, the student must simply first recall that the period of rotation is considered one day. Once this constraint is identified, the test taker need only identify the lowest number (decision making).

**Question 8**

The student is asked to respond with an extended answer in his or her own words. He or she must draw the connection between the great distances separating celestial objects and the large distance light travels in a year and then conclude that the light year is the unit used by astronomers to measure distance in space.
Identifying the relationship and drawing the correct conclusion requires *reasoning*.

**Question 9**
The test taker is required to exhibit a basic understanding of telescope operation to answer the question of why the Hubble Telescope can take clear pictures. He or she might be able to answer correctly based on simple recall or may draw the connection between the location of many earth bound telescopes (on mountaintops and/or in desert areas) and the effect of the atmosphere on telescope images. In this latter case, *reasoning* would be used to determine the correct answer.

**Question 10**
The student is presented with two pictures of the night sky taken one week apart. Clearly only one object has changed position. He or she must use logic to conclude that this one object is closer to the earth (*reasoning*), then evaluate the four possibilities as to what this object might be (*decision making*).

**Question 11**
Addressing a classic misconception held by many, Question 11 asks the test taker about the relationship of the position of the earth relative to the sun and the season in Ohio. Once again, *reasoning* is needed to mate the relationship of the inclination of the earth with the directness of the sun’s rays. Once this connection is made, the student must next recognize that the drawing presented depicts North America (and Ohio) as receiving less direct sunlight and, thus, less heat from the sun. This requires *mental visualization*. Within these parameters, he or she must
decide \textit{(decision making)} which of the four seasons best matches the conditions set in the picture.

\textbf{Question 12}

This is a genetics question requiring knowledge of the Punnet square and is most easily answered correctly by simple recall of how a Punnet square is used. However, this author believes that a talented student with no knowledge of Punnet squares could use \textit{creative thinking} to arrive at the correct answer. Since the information provided gives both the phenotype and genotype of both parents, the test taker could connect the haploid representation of the parents’ eggs and sperm to recognize the correct square.

For the average test taker, it is highly unlikely that he or she will be able to bridge this gap to make the connection. As a result, this question will be counted as simple recall.

\textbf{Question 13}

A curved plant tip showing rectangular cells of varying length and the position of a light source are presented. One might think that knowledge of the principle of growth hormone action on the “shaded” side of the tip in necessary to arrive at the correct answer. However, the answer can be discerned by a just a thorough and complete examination of the drawing using the four selectors as a guide. \textit{Mental visualization} is the critical thinking ability needed to accomplish this.

\textbf{Question 14}

The test taker is presented with task of predicting why giraffes have long necks. He or she must use \textit{creative thinking} to connect the ideas that 1) giraffes are herbivores and 2) some vegetation beneficial to the diet of the giraffes might be farther from the ground and better reached with a long neck.
Question 15

Given the density of water, oil, and a ball, the student must choose which of four pictures would best represent the result if the three were placed in one container. **Reasoning** is required to arrive at their positions in one container relative to each other and **mental visualization** must be used to organize the graphic representations to match the required principle of density.

Question 16

A table of five metals and water and their respective specific heats is presented in a straightforward table. The test taker must conclude the substance with the highest specific heat would absorb the most heat with the least temperature change (**reasoning**) and the find the substance with the highest specific heat (**decision making**).

Question 17

Questions 17, 18, and 19 involve a table of data showing the result of an experiment with bread mold. Two critical thinking abilities are needed to correctly answer question 17. The test taker must use **mental visualization** to process the data presented and define the constraint, then **decision making** to choose the best alternative that fits the conditions specified in the question.

Question 18

The student is presented with a second constraint and, again, must use **mental visualization** to process the data presented and define the constraint, then **decision making** to choose the best alternative that fits the conditions specified in the question.
Question 19
The student is asked to predict how the confidence in the experimental results could be increased. Generating this prediction requires creative thinking.

Question 20
Questions 20 through 24 are based on a graph of red worm growth against time in months. Two sets of data are depicted on the graph representing two students raising red worms. Question 20 requires the test taker to use mental visualization to interpret the data to determine the month of highest population density for student 2’s worm bed.

Question 21
A hypothesis is stated and the student is asked to conclude whether or not the data supports the hypothesis. Reasoning is presented in each of the four possible answers. Drawing conclusions from the available data is a clear use of the critical thinking ability reasoning.

Question 22
The student is asked to offer an explanation for the large drop in population of Student 2’s worm bed from March to April. He or she must take imagine a new possibility from the given information; requiring creative thinking.

Question 23
Another variable in the form of houseflies was added to the worm bins and the test taker must determine what interaction, if any, would result. Drawing the conclusion that the flies would act as a competitor based on the common food requirements requires reasoning.
Question 24

The student must predict whether the systems were self-sustaining. *Creative thinking* is required to combine separate ideas to make this prediction.

Question 25

The test taker must use *mental visualization* to process information in one table and apply the information on a map. He or she must then predict the day the hurricane will hit land after the path of the hurricane is plated on the map. To generate the idea of predicting land fall requires the use of *creative thinking*. This is a free response question requiring an explanation of the reasoning used to arrive at the answer.

Question 26

Questions 26 and 27 utilize a table of data on the eating recommendations for five species of fish in five Ohio rivers. The SCANS guidelines once again suggest *mental visualization* is required to process the information in the table. To select the river most contaminated with PCBs, the student must evaluate the data, generate a constraint, and decide on the best of the alternatives. This suggests the use of *decision making*.

Question 27

The test taker is asked to choose the human body system interfered by hormone disruption caused by PCBs. Although the directions state that question 27 is based on a passage and table, the passage and table are not required to answer the question correctly. Choosing the correct answer involves recalling which of the four given systems produce hormones. Therefore, no critical thinking abilities are used.
Question 28
A graph of percentage of light absorbed plotted with wavelength of light is presented along with a table of visible light wavelengths and their appropriate colors. The student must use mental visualization to process the data and reasoning to identify the relationship between the position of the graph line and the color of the wavelength least helpful to plant growth. Finally, after these constraints are set, decision making is used to choose the alternative best fitting the constraints.

Question 29
This question is almost identical to question 28. However, test taker need not use reasoning to arrive at the correct answer. Because of data represented in the graph, mental visualization is required followed by decision making in a manner similar to question 28.

Question 30
The student reads a short paragraph concerning the shift of energy sources between 1900 and 1970. He or she is asked to respond to advantages and disadvantages of switching further to solar power. Several principles of energy usage must be recalled to first form a response. Reasoning would be called upon to link the several ideas involved and to form one conclusion each for an advantage and disadvantage.

Question 31
A diagram is presented illustrating the position of four types of rock formations and the test taker must determine which formation is the youngest. Because information is presented in a drawing requiring interpretation, mental visualization is utilized to process the facts. Drawing the conclusion that the
youngest formation lies nearest the surface calls upon reasoning.

Question 32
To determine in which type of rock are fossils least likely to found, the student uses his or her reasoning skills to form a conclusion based on two or more earth science principles.

Question 33
The test taker is presented with a passage and map of Iceland showing the Mid-Atlantic Ridge and the North American and Eurasian Plates for questions 33-34. Question 33 asked the student to form a conclusion about magma convection currents. He or she must logically conclude why one fluid rises above a surrounding fluid, another example of reasoning.

Question 34
The student is asked to form a conclusion using the sea floor spreading concept and the possible age of rock formations in different areas of Iceland. Once again, reasoning is called upon to form this conclusion.

Question 35
The test taker is presented with four possible drawings of a volcano showing the temperatures of three areas of the volcano. Organizing and processing the information in the drawings requires mental visualization. Using principles of magma movement, the students form a conclusion from the available information using reasoning.

Question 36
A short passage stating Aristotle’s and Newton’s positions concerning friction and motion is given. The student is then presented with a situation and asked to tell what would happen according to both Aristotle and Newton. Because connecting two different ideas applied to a new situation forms a new idea, creative thinking is required.
Question 37
The test taker is presented with a force situation in physics in the form of a drawing. He or she must respond in essay form to best describe the resultant motion. He or she must interpret the drawing which requires mental visualization the use logic to predict the action, an example of reasoning.

Question 38
An electromagnetic spectrum is present which requires mental visualization to organize the information. The student must analyze the information represented to relationships stated in the four responses. Both reasoning and decision making are needed to locate relationships among wavelength, frequency, and energy and then to generate the best alternative.

Question 39
To determine the path of reflected light through glass, the student most likely simply recalls that light is refracted at an angle through the medium through which it passes. This alone is enough to correctly answer the question. No critical thinking is required.

Question 40
A sort passage and temperature/time graph of the heat absorbing ability of four colors of fabric is presented. The student must use mental visualization to process the data in the graph to select the response correct to the question asked.
Question 41

This question relates to the same passage and graph. The test taker must predict why the lines in the graph for all four colors flatten out after a period of time. To imagine a new possibility from the information given requires creative thinking.

Question 42

The question also seeks a prediction from the student. This time he or she must choose the color of a solar collector based on the information in the graph. Mental visualization is needed to sort the data for information on maximum absorption. Since the question states that choosing the color for maximum absorption is the goal, no other critical thinking abilities are needed.

Question 43

From a section of the periodic table, the test taker must select the one element of four with the greatest atomic mass. Since the table has atomic mass clearly identified, a simple form of decision making is all that is needed.

Question 44

The student is asked why helium is used for blimps instead of hydrogen. Since information needed to answer is not included on the periodic table, he or she must recall that hydrogen is flammable while helium is not reactive. No critical thinking abilities are used.

Question 45

The student must choose between two sources of water as to which is more likely to be pure and must respond with the reasoning behind his or her decision. Reasoning is required to arrive at the underlying relationships of the two sources and to draw the correct conclusion.
**Question 46**
The student is presented with the possible bacterial contamination of water and asked to choose the response that represents the step that should be followed before drinking. Choosing the best alternative requires the application of one basic principle of bacteriology. Since this is more recall than using critical thinking, it appears to be a simple recall situation at first. However, the student must apply the principle to this situation and this requires *decision making*.

**Question 47**
The student is presented with a pie chart of where scrap tires go and decides which response is supported by the data presented in the chart. *Mental visualization* is required to process the data and *reasoning* is used to analyze the data and responses and form a conclusion.

**Question 48**
The student must select one of four responses that will probably increase soil erosion the most. To identify the relationship of the principles involved, he or she calls upon *reasoning skills*, then *decision making* to evaluate each response and choose the one most supported by the principle of erosion.

**Question 49**
A drawing of DNA fingerprints of four zoo lions and a short passage is presented and the test taker is asked to identify the sire of a lion cub. *Mental visualization* is called upon to sort out the data of the four possible sires and cub in the drawing. Matching the cub’s DNA fingerprint to one of the possible sires requires *decision making*. 
Question 50

The test taker is presented with a make believe animal and a passage describing the animal’s special features. He or she must identify the natural habitat for which the animal is best suited and explain reasons for the selection in an open-ended response. *Reasoning* is required to match the special features with a particular environment.
APPENDIX E

TABLE OF CORRELATION COEFFICIENTS
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<td>SE</td>
<td>186</td>
<td>.0645</td>
<td>.25</td>
</tr>
<tr>
<td>SW</td>
<td>186</td>
<td>.2366</td>
<td>.43</td>
</tr>
<tr>
<td>MAN</td>
<td>187</td>
<td>.4920</td>
<td>.50</td>
</tr>
<tr>
<td>SER</td>
<td>187</td>
<td>.2032</td>
<td>.40</td>
</tr>
<tr>
<td>RET</td>
<td>187</td>
<td>.1176</td>
<td>.32</td>
</tr>
<tr>
<td>OTHER</td>
<td>187</td>
<td>.1872</td>
<td>.39</td>
</tr>
</tbody>
</table>


SCIENCE TEST

50 Questions-Maximum Time Allowed is 2 ½ Hours

Directions: Most of the questions on this test are associated with a passage, table, graph or figure. Some of the questions are clustered together. Other questions stand alone. When you respond to short-answer and extended-response items, use the space provided in your answer document. You may respond using written text and other representations of information such as drawings, charts, graphs and/or maps. You do not need to use all of the space provided, but be sure your answers are complete. When responding to multiple-choice questions, choose the best answer to each question and blacken the corresponding space in your answer document. You may refer to passages, tables, graphs and figures as often as necessary.

Questions 1-2 are based on the following passage

In the nineteenth century Robert Koch scientifically investigated the transmission of diseases. He proposed a procedure that would enable a person to determine if a specific microorganism caused a given disease. The first four steps of this procedure are listed below:

1. Microbes must be isolated from an infected host organism.
2. The isolated microbes are then grown in a pure culture.
3. The microbes from the pure culture are injected into a new host.
4. If the new host contracts the disease, the microbes must be isolated from the new host and grown in a new culture.

1. What final step should be taken to prove that these specific microbes cause the given disease?
   A. Mix the microbes from the new and old cultures
   B. Inject diseased organisms with the microbe from the new culture
   C. Compare the original microbes with the microbes in the new culture.
   D. Inject an organism immune to the disease with microbes from the new culture.

2. Robert Koch isolated bacteria and injected them into an animal to see if they caused a disease. His studies led most directly to the discovery of
   A. vitamins
   B. antibiotics
   C. nucleic acids
   D. genetic diseases
Freezing Solutions

The freezing temperature of pure water is 0°C. A group of students performed an experiment to see if the solutions made by adding various types and amounts of solids to water had different freezing temperatures than pure water. The students dissolved various amounts of four different solids in 1,000 grams of water and then measured the freezing temperatures of the resultant solutions (see table below).

<table>
<thead>
<tr>
<th>Grams of Solid added to 1,000 g Water</th>
<th>Cesium Chloride</th>
<th>Sodium Chloride</th>
<th>Calcium Chloride</th>
<th>Sodium Hydroxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>−1.0°C</td>
<td>−2.9°C</td>
<td>−2.2°C</td>
<td>−4.4°C</td>
</tr>
<tr>
<td>100</td>
<td>−1.9°C</td>
<td>−5.9°C</td>
<td>−5.1°C</td>
<td>−9.3°C</td>
</tr>
<tr>
<td>150</td>
<td>−2.7°C</td>
<td>−9.0°C</td>
<td>−8.7°C</td>
<td>−15.0°C</td>
</tr>
<tr>
<td>200</td>
<td>−3.6°C</td>
<td>−12.6°C</td>
<td>−13.2°C</td>
<td>—</td>
</tr>
</tbody>
</table>

Note: a dash (−) indicates that the students did not perform this trial.

Questions 3-5 are based on the following passage and table.
3. Which of the following graphs best represents the freezing temperature data for the cesium chloride solution shown in the table?

4. If the students added 250 g of calcium chloride to 1,000 g of water, the freezing temperature of this solution would most likely be between

A. -2.0°C and -5.1°C.
B. -5.3°C and -8.7°C.
C. -8.8°C and -13.2°C.
D. -13.3°C and -18.5°C.

5. Sodium hydroxide is very reactive. If some of the sodium hydroxide solution splattered onto their hands during the experiment, the students should have

A. wiped it off with a dry towel.
B. washed it off with a large amount of water.
C. immediately covered it with a bandage and kept the spot warm.
D. done nothing because the sodium hydroxide was already neutralized by the water.
The First Five Planets from the Sun

<table>
<thead>
<tr>
<th>Planet</th>
<th>Mean Distance from Sun (millions of km)</th>
<th>Orbital Period of Revolution (Earth time)</th>
<th>Period of Rotation (Earth time)</th>
<th>Equatorial Diameter (km)</th>
<th>Density (g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>57.9</td>
<td>88 days</td>
<td>59 days</td>
<td>4,880</td>
<td>5.4</td>
</tr>
<tr>
<td>Venus</td>
<td>108.2</td>
<td>224.7 days</td>
<td>243 days</td>
<td>12,104</td>
<td>5.2</td>
</tr>
<tr>
<td>Earth</td>
<td>149.6</td>
<td>365.3 days</td>
<td>23 hours 56 minutes</td>
<td>12,756</td>
<td>5.5</td>
</tr>
<tr>
<td>Mars</td>
<td>227.9</td>
<td>687 days</td>
<td>24 hours 37 minutes</td>
<td>6,787</td>
<td>3.9</td>
</tr>
<tr>
<td>Jupiter</td>
<td>778.3</td>
<td>11.86 years</td>
<td>9 hours 50 minutes</td>
<td>142,800</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Questions 6-7 are based on the following table.

6. The period of revolution of a planet is most closely related to its
   A. density.
   B. period of rotation.
   C. equatorial diameter.
   D. mean distance from the sun.

7. Which of these planets has the shortest day?
   A. Mercury
   B. Venus
   C. Mars
   D. Jupiter
Questions 8-16 are NOT related.

8. Why do astronomers often use light-years instead of kilometers to describe distances between celestial objects? Respond in the space provided in your Answer Document.

9. The Hubble Space Telescope is a high-powered astronomical observatory orbiting the Earth at an altitude of about 600 km. Using Hubble, scientists have photographed what appears to be the first planet ever seen outside the solar system. What is the main reason the Hubble Telescope is able to take such clear pictures?
   A. It is always nighttime in space.
   B. There is little atmosphere to hinder Hubble’s view.
   C. Hubble is closer to the stars than an earthbound telescope.
   D. Hubble is made of higher quality components than earthbound telescopes.
Use the diagram to answer question 10.

10. A student drew these diagrams of the night sky on the dates shown. The object X that he drew is probably a
A. meteor.
B. planet.
C. supernova.
D. variable star.
11. The diagram shows the position of the earth relative to the sun. What is the season in Ohio when the earth is in the position shown in the diagram?

A. Summer
B. Fall
C. Winter
D. Spring
12. In certain breeds of dogs such as the Mexican Hairless, having hair is the result of having two dominant alleles for normal hair (NN). The heterozygous genotype (Nn) produces a dog with very little hair and few teeth. Having two recessive (nn) genes results in a stillborn puppy. Which Punnett square shows the correct results of a cross between two heterozygous Mexican Hairless dogs? Use the diagram to answer question 13.

A. 

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Nn</td>
<td>Nn</td>
</tr>
<tr>
<td>n</td>
<td>Nn</td>
<td>nn</td>
</tr>
</tbody>
</table>

B. 

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Nn</td>
<td>Nn</td>
</tr>
<tr>
<td>n</td>
<td>nn</td>
<td>nn</td>
</tr>
</tbody>
</table>

C. 

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>NN</td>
<td>Nn</td>
</tr>
<tr>
<td>n</td>
<td>Nn</td>
<td>nn</td>
</tr>
</tbody>
</table>

D. 

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>NN</td>
<td>NN</td>
</tr>
<tr>
<td>n</td>
<td>Nn</td>
<td>Nn</td>
</tr>
</tbody>
</table>

13. An experiment was set up to test the effects of light on the growing tip of a plant. The diagram shows a longitudinal section of the growing plant tip. Which of these observations correctly describes the results?

A. The cells farther away from the light source are longer than the cells facing the light.

B. The walls of the cells farther away from the light source are thicker.
C. There are more cells on the side of the plants facing away from the light source.

D. The cells in the center of the plant are more flexible than cells on the sides.

14. Giraffes have longer necks than other herbivores. This trait is probably most important for

A. sleeping while standing up.

B. detecting prey at great distances.

C. Conserving water during droughts.

D. Gaining access to different food sources.

15. In a lab the density of water, oil, and a plastic ball were found. Water has a density of 1.0 g/mL. Oil has a density of 0.80 g/mL. The plastic ball has a density of 1.2 g/mL. Which picture best represents the result if water, oil, and the plastic ball are placed in the same container?
16. Students experimentally verified the specific heat of various materials and recorded the data in the table shown below.

<table>
<thead>
<tr>
<th>SUBSTANCES</th>
<th>SPECIFIC HEAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>899 J/kg °C</td>
</tr>
<tr>
<td>Copper</td>
<td>385 J/kg °C</td>
</tr>
<tr>
<td>Iron</td>
<td>451 J/kg °C</td>
</tr>
<tr>
<td>Nickel</td>
<td>442 J/kg °C</td>
</tr>
<tr>
<td>Water</td>
<td>4190 J/kg °C</td>
</tr>
<tr>
<td>Wood</td>
<td>1660 J/kg °C</td>
</tr>
</tbody>
</table>
Based on the data collected, the substance that would absorb the most heat energy with the least temperature change would be one kilogram of

A. aluminum.
B. water.
C. copper.
D. iron.

Questions 17-19 are based on the following table.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Amount of mold after two weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp. (°C)</td>
<td>Humidity</td>
</tr>
<tr>
<td>0</td>
<td>Low</td>
</tr>
<tr>
<td>0</td>
<td>High</td>
</tr>
<tr>
<td>5.5</td>
<td>Low</td>
</tr>
<tr>
<td>5.5</td>
<td>High</td>
</tr>
<tr>
<td>25.5</td>
<td>Low</td>
</tr>
<tr>
<td>25.5</td>
<td>High</td>
</tr>
</tbody>
</table>
17. According to the data, what are the best conditions for growing mold?
A. cold temperature and low humidity
B. cold temperature and high humidity
C. warm temperature and low humidity
D. warm temperature and high humidity

18. Which of these conditions may prevent mold from growing?
A. low humidity
B. high humidity
C. warm temperatures
D. freezing temperatures

19. How could confidence in the results of the experiment be increased?
A. Several kinds of bread could be tested.
B. Several brands of bread could be tested.
C. The experiment could be repeated with dry toast.
D. The experiment could be repeated without any changes.

Questions 20-24 are based on the following passage and graph.

Composting

As part of a class exercise on composting, two students constructed identical worm bins (containers), which they kept at their homes. Red worms were then added to the bins. Both students counted the number of red worms in their bins on the first of the month. The results are shown in the graph below.
A worm bin should be kept between 12°C and 25°C and 2.5 kg of food should be added to a bin each week. Student 1 followed these requirements exactly. During December, Student 2 left town for three weeks; during March, the temperature in Student 2's worm bin reached 30°C.

20. The highest population density of red worms in Student 2’s bin was reached at the beginning of
A. November
B. December
C. March
D. May

21. It was hypothesized that there was a maximum number of red worms that could survive in the worm bins. Is this hypothesis supported by the data in the graph?
A. Yes, because the number of red worms in Students 1’s bin remained fairly constant between December and May.
B. Yes because the number of red worms in Student 2’s bin continued to increase between September and May.
C. No, because the number of red worms in Student 1’s bin decreased between December and May.
D. No because the number of red worms in Student 2’s bin decreased between November and January.
22. Which of the following probably accounted for the large drop in population in Student 2’s bin from March to April?

A. overpopulation  
B. overheating  
C. lack of food  
D. lack of water

23. Suppose several houseflies were allowed to enter the worm bins and feed on the food scraps. Which of the following interactions would most likely occur between the houseflies and the red worms?

A. predation  
B. parasitism  
C. competition  
D. commensalism

24. Are the systems established in the compost bin self-sustaining?

A. No, because red worms did not reproduce.  
B. No, because the students need to provide energy to the systems in the form of food.  
C. Yes, because once the compost bins were established, the students did not have to add anything else to them.  
D. Yes, because the red worms reproduced.
TRACKING A STORM
The chart below shows the latitude, longitude, and wind speed of a tropical weather system.

<table>
<thead>
<tr>
<th>Date</th>
<th>Latitude Degrees (north)</th>
<th>Longitude Degrees (west)</th>
<th>Wind Speed (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug. 31</td>
<td>28</td>
<td>75</td>
<td>70</td>
</tr>
<tr>
<td>Sept. 01</td>
<td>29</td>
<td>78</td>
<td>65</td>
</tr>
<tr>
<td>Sept. 02</td>
<td>31</td>
<td>79</td>
<td>65</td>
</tr>
<tr>
<td>Sept. 03</td>
<td>33</td>
<td>79</td>
<td>70</td>
</tr>
</tbody>
</table>

Use the chart and map to answer question 25.
25. As tropical storms gain in strength they are tracked by the weather service and by many people living in coastal areas. The chart above provides data on one hurricane. If the hurricane continues to move in the same direction, on what day will the hurricane probably hit land? Explain how you were able to make this prediction. Respond in the space provided in your Answer Document.

**Recommended Restrictions for Eating Selected Sport Fish (PCB Advisory)**

<table>
<thead>
<tr>
<th>Fish Species</th>
<th>Lake Erie</th>
<th>Ashtabula River</th>
<th>Maumee River</th>
<th>Ottawa River</th>
<th>Portage River</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carp under 20 inches</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Carp 20+ inches</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Channel Catfish</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Freshwater Drum</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Lake Trout</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Largemouth Bass</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

**Key**

1 = No Restriction  
2 = One Meal per Week  
3 = One Meal per Month  
4 = Six Meals per Year  
5 = Do Not Eat!

Questions 26-27 are based on the following passage and table.

**Lake Erie**

Lake Erie has suffered long term pollution problems. While the situation is improving for this Great Lake, there are still areas of concern. The table below shows an advisory from the early 1990s for eating fish taken from Lake Erie that may contain PCBs.

26. Which Lake Erie tributary is probably most contaminated with PCBs?  
A. Portage River
B. Ottawa River

C. Maumee River

D. Ashtabula River

27. PCBs that disrupt hormones in humans are interfering with the

A. nervous system.

B. immune system.

C. endocrine system.

D. circulatory system.

Questions 28-29 are based on the following graph.

28. An experiment was conducted to test the growth rate of a plant under different light conditions. What color of light would probably be the least helpful for this plant’s growth?

A. violet

B. blue

C. green

D. red

29. The most light absorbed by this plant is

A. violet and red.

B. blue and red.

C. green and yellow.

D. blue and green.
Questions 30-32 are NOT related.

30. Between 1900 and 1970, the United States experienced a major shift from getting power from wood and coal to getting power from oil and natural gas. Describe one advantage and one disadvantage that might be experienced if the United States shifted from an oil and natural gas powered society to a solar powered one. Respond in the space provided in your Answer Document.

Use the diagram to answer question 31.

31. On a field trip, a student observes a hillside that has been cut away for a road. From the student's diagram, which of these formations is the youngest?
315

A. sandstone formation
B. igneous formation
C. shale formation
D. limestone formation

32. In which type of rock are fossils least likely to occur?
A. granite
B. limestone
C. sandstone
D. shale

Questions 33-35 are based on the following passage and map.
Iceland was settled by the Vikings more than one thousand years ago. At the time Iceland was apparently covered with forests, but these have disappeared as people invaded the small bits of land not covered by glaciers or solid rock. This is a land of ice and heat, heat from active volcanoes.

The map shows Iceland with the Mid-Atlantic Ridge running through it. This ridge is formed by two tectonic plates that are moving apart at an average rate of 2.5 centimeters per year. As the ocean crust spreads, magma rises up into the gap and hardens to form new crust. Along the ridge are strings of volcanoes, some of which formed islands such as Iceland.

33. The magma convection currents within the earth are due primarily to the fact that fluids will rise if the surrounding fluid is a greater
A. density.
B. volume.
C. temperature.
D. atomic number.

34. Due to the spreading of the tectonic plates, rocks from the center of Iceland, when compared to rock formations making up its eastern and western coasts, are found to be
A. denser.
B. harder.
C. more magnetic.
D. younger.

35. The pictures below show a simplified view of the rock temperatures in and around a volcano. Which of the pictures correctly shows the direction of heat flow in the rock?

Questions 36-39 are NOT related.

36. Aristotle thought that a moving object would stop because its natural state was to be at rest. Newton thought that friction is a force that opposes all motion and eventually stops moving objects. Suppose you were coasting on a level surface on a bicycle and there was NO friction. What would happen to your speed, according to Aristotle and Newton?
A. Aristotle: slow and stop; Newton: slow and stop
B. Aristotle: maintain speed; Newton: maintain speed
C. Aristotle: slow and stop; Newton: maintain speed
D. Aristotle: slow and stop; Newton: maintain speed
Use the diagram to answer question 37.
37. The diagram illustrates a large, constant force being applied to a ball. Students are observing the ball, making measurements and recording the data.

What are the best measurements to make and record in order to describe the motion of the ball? In their report, how should the students organize (display) the data to describe the ball's motion? Respond in the space provided in your Answer Document.

Use the electromagnetic spectrum to answer question 38.
38. According to this chart, the longer the wavelength

A. the faster the wave travels.
B. the less energy the wave has.
C. the larger the amplitude of the wave.
D. the greater the frequency of the wave.

Use the diagram to answer question 39.
39. Which of these arrows would represent the path of a refracted ray of light?

A. A
B. 
C. 
D. 

Questions 40-42 are based on the following passage and figure.

Hot
During the summer a student noticed the color of the clothes she wore affected how hot she felt. The student designed an experiment to test this.

The student obtained four identical samples of sand. Each sample was covered with a different color of cotton fabric. Each sample was then placed directly under a 110-watt lightbulb. The student recorded the initial temperatures of the sand, then turned on the lamps. At one-minute intervals, for six minutes total, the student measured the temperature of each sample. The data are shown in the graph below.
40. According to the graph, which sample had the lowest final temperature?

A. pink
B. white
C. purple
D. black

41. Which of the following best explains why the curves in the figure flattened out after a period of time?

A. The light bulbs ran out of electricity to supply to the samples.
B. The samples began to reflect all of the light energy.
C. The samples began to absorb all of the light energy emitted by the light bulb.
D. The samples were releasing energy at about the same rate as they were absorbing energy.

42. Solar collectors are used to absorb energy from the sun. This energy is then used to heat homes. According to the data from this experiment, what color should solar collectors be to maximize energy absorption?
A. white
B.
C.
D.
Questions 43-44 are based on the following table.

43. Which of these elements has the greatest atomic mass?
   A. hydrogen
   B. helium
   C. fluorine
   D. sodium

44. Both hydrogen gas and helium gas are lighter than air. Why is helium used to lift blimps instead of hydrogen?
   A. Hydrogen has a tendency to lose an electron, decreasing lift.
   B. Helium is more chemically stable than hydrogen and will not burn.
   C. Hydrogen has less lifting force than helium because it has less mass.
   D. Helium has more lifting force than hydrogen because it has more electrons.
Questions 45-50 are NOT related.

45. Which is more likely to be pure: water from a kitchen faucet or the water that collects on the outside of a clean glass containing iced faucet water? Explain the reasoning behind your answer. Respond in the space provided in your Answer Document.

46. An underground sewer pipe has burst near the pipe that supplies clean water to your neighborhood. The water company is not sure if bacterial contamination has occurred. What step should you take before drinking tap water?

A. Freeze water overnight and let it thaw.
B. Boil water for 10 minutes and let it cool.
C. Only drink water from a neighbor’s faucet.
D. Carefully wash all glasses with soap and water.

Use the circle graph to answer question 47.

47. What inference is supported by the information in the graph above?

A. Only 10.7 percent of all landfills have a permit to burn tires.
B. About one-third of all scrap tires are either exported or recycled.
C. Most scrap tires are illegally dumped to avoid tire disposal fees.
D. The supply of scrap tires is greater than the reuse of scrap tires.
48. Which of these events will probably increase soil erosion the most?

A. removing leaf litter from a dense forest
B. mowing open fields of grass on a regular basis
C. trimming bushes so the branches will be off the ground
D. cutting vines from trees

Use the partial DNA fingerprints to answer question 49.

49. A veterinarian for a zoo wanted to determine the pedigree of a lion cub born at the zoo. Four male adult lions had to be considered as possible sires of the cub. DNA testing was conducted and partial DNA fingerprints are shown above. Based on this data, which male lion most likely sired the cub?

A. Streak
B. Goldy
C. Wilbur
D. Matt

Use the picture to answer question 50.

50. The picture above shows a make-believe, long furry animal. The animal's head is small compared to its long body. The head has two tiny ears, a flat nose, and a mouth with broad, flat teeth. The four long, slender legs end in large, webbed feet with four bulbous toes on each foot. The long tail has a tufted end. Describe the type of natural habitat the animal is best suited for. Identify and explain four traits showing how the animal is best suited for its environment. Respond in the space provided in your Answer Document.
APPENDIX H

LIST OF ACRONYMS
ACT – American College Testing
ASTD – American Society for Training and Development
CCTST - California Critical Thinking Skills Test
CCTT - Cornell Critical Thinking Test
CT – critical thinking
ELE – entry-level employees
EWCTET - Ennis-Weir Critical Thinking Essay Test
HOTS - Higher Order Thinking Skills
NJTRS - New Jersey Test of Reasoning Skills
OSGI – Ohio Skills Gap Initiative
RTHCP - Ross Test of Higher Cognitive Processes
SCANS – Secretaries Commission for Achieving Necessary Skills
WGCTA - Watson Glaser Critical Thinking Appraisal