A Study of Creative and Critical Thinking Abilities of Traditional as Compared to New Problem Solving Programs in Technology Education

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A STUDY OF CREATIVE AND CRITICAL THINKING ABILITIES OF TRADITIONAL AS COMPARED TO NEW PROBLEM SOLVING PROGRAMS IN TECHNOLOGY EDUCATION

A RESEARCH PROJECT PRESENTED TO THE FACULTY OF THE COLLEGE OF EDUCATION OLD DOMINION UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE MASTER OF SCIENCE IN EDUCATION

By Edward L. Welliver, M.S. August, 1990
This project was prepared by Edward L. Welliver under the direction of Dr. John M. Ritz in VTE 636, Problems in Education. It was submitted to the Graduate Program Director as a partial fulfillment of the requirements for the Master of Science in Education Degree.

Approved By:

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Dr. John M. Ritz, Advisor and Graduate Program Director

Date 7-27-90
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CHAPTER I
INTRODUCTION
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INTRODUCTION

For years Industrial Arts, as well as many other forms of traditional education, has followed a tightly structured, step-by-step approach to instruction that does little to stimulate its students' creativity. We, throughout our own education, have been conditioned to closely follow instructions given us by teachers in order to reach a desired goal or outcome. Today and even more so in the future, as members of the world's work force, students will be called upon to find the answers to problems that do not have set instructions or predetermined goals. Year after year it becomes more important for us to help students develop their own creativity and curiosity in order to prepare them for such challenges as these (Ritz, 1989, p.1).

Industrial arts education's role has always been one of applied theories; however, the traditional methods in which it has been taught will no longer be sufficient. Traditionally, we have set goals for student achievement and supplied the student with a map specifying how to reach these goals. With the recent push for excellence in education, there is little room for a curriculum or discipline that produces less than excellent thinkers or mere instruction followers.

The trend in practical education is toward Technology Education with problem solving as its main directive and away from traditional Industrial Arts approaches. The new programs are devised to help stimulate the student's creativity and decision-making abilities. The problem solving oriented programs teach theories and processes as does its traditional counter
part, however the student is encouraged to make calculated decisions on procedures to be used in obtaining the desired goals.

Presently in Chesapeake (Virginia) Public Schools, the junior high school Technology Education programs are divided as to the approach in which curriculum goals are being obtained. This research study will examine five junior high school programs, three of which are examples of traditional type approaches and the other two, examples of "Twenty-first Century Labs" with problem solving based curriculums. The study will examine the approaches of traditional project based as compared to the problem solving based curriculums. The students of the two systems will be tested on their creative abilities toward reaching goals through problem solving.

Statement of the Problem

The problem of this study was to compare traditional Industrial Arts and new Technology Education instructional methods and their affects on the problem solving abilities of the students of five junior high schools in Chesapeake, Virginia.

Research Goal

Hypothesis: The research contained in this study will demonstrate that the innovative approach to problem solving in education, characteristic of the "new" Technology Education programs, is more effective in stimulating students' creativity and decision-making abilities than is traditional Industrial Arts instruction.
Background and Significance

The United States, at the end of the industrial revolution, was king of a very important mountain. We saw our countrymen introduce some of the most innovative ideas of man's existence. We were witness to the invention of interchangeable parts, man's first flight, and, with the harnessing of electricity, the rise of the U.S. to world leader of technology (Boucher, 1988).

In the late 1950's, the United States found itself in a tight technological race with many countries throughout western Europe and the rest of the world. This race for technological superiority spawned a surge for a more technically oriented education system in the U.S. Throughout the sixties and seventies, involvement in the space program as well as the Vietnam War contributed to the United States' deeper penetration into high technology. During the 1980's the microcomputer's domination of the world of technology began, extending even greater challenges.

As we begin the decade of the nineties, the importance of educating our future citizens in technologies of the future becomes more apparent. At current rates of change, our technology and knowledge accompanying it is doubling every two years. By the end of this century ninety percent of the knowledge appropriate to its time is yet to be created (Barnes, 1989). With all the economic pressures facing our nation at this point, and the obstacles ahead of us, it is imperative that we begin producing graduates that are functional, technically literate members of society.

"Traditional Industrial Arts programs, which focused primarily on developing manipulative skills and understanding about industrial materials and processes"... (Johnson, 1989, p.9), "content based", are no longer
appropriate. The new Technology Education programs, in which the student is presented with a view of technology on a broader scale and aimed at developing the student's problem solving skills, will produce the technically literate members of the work force that the future demands.

The future of the United States depends greatly on the success of her schools' production of the appropriately educated graduates necessary to fill the jobs of the future. "The growth in science and technology has provided . . . a totally different perspective that calls for a different approach to understanding . . . technical means" (Lauda, 1984). The appropriate approach to instruction for the future is defined in the new curricula set forth in Technology Education programs with problem solving as their process for learning.

Limitations

The following are limitations that should be considered when reviewing this research study:

1. Even though the student groups to be tested are subject to identical curriculum guides and competencies, they are from different school zones and may have different socioeconomic backgrounds.

2. The teachers presenting materials to the different groups, though following the same competencies lists and curriculum, are indeed different human beings and may possess different levels of effectiveness in transmitting the subject matter.

3. The students participating in this research are from predominantly suburban and rural, Southeastern Virginia, neighborhoods and the results may not be consistent with results obtained from large urban areas.
4. The students are all from suburban and rural areas of Chesapeake, Virginia; however, it can be assumed that the students have been raised in similar environments.

Assumptions

When considering the groups and conditions in which the research was conducted, certain things must and may be assumed. The following are assumptions that have been made for this study:

1. The teachers of each group of students are subject to a curriculum and a subsequent list of competencies; therefore, it may be assumed that the student groups have been presented with approximately the same material.

2. Student participants ages all range between 12 to 13, thus we may assume that the level of maturity is similar among the students.

3. Problem solving caters to the individual, and may have many different solutions to the same problem. This approach has no right or wrong answers, just success or failure in reaching a workable solution to the problems posed.

4. The "Cornell Critical Thinking Test" is a highly regarded, published test therefore it can be assumed that it is a better than adequate test for students' creative and critical thinking abilities.

Procedures

The research in the following study was devised to test the creative thinking and problem solving abilities of the students in five junior high school Technology Education programs in Chesapeake Public Schools. Three of these schools, Great Bridge Junior High School, Indian River Junior High School and Deep Creek Junior High School, are using the traditional
"project" method of teaching seventh grade Technology Education. Crestwood and Western Branch Junior High Schools are using "problem solving" methods to teach their seventh grade Technology Education classes.

Using the "Cornell Critical Thinking Test, Level X", each of the students of the seventh grade Technology Education classes of the five schools were tested as to their abilities in problem solving and creative thinking. The scores of the traditional group were compared to the scores of the groups receiving instruction using the new methods. The two sets of scores were compared, using the statistical t-test, to determine which method of instruction is the most effective in producing high levels of creative thinking and problem solving abilities, thus determining which is the better teaching method to guide our education into the future.

Definition of Terms

The following information is provided to insure that the reader of this study has an understanding of terms used that may be abstract or unfamiliar.

Traditional Industrial Arts Instruction - Traditional instruction in Industrial Arts Education is a project based approach in which the student is supplied with specific procedures to be followed in attaining the curricular goals.

Technological Problem Solving Instruction - The "new" problem solving approach presents the student with various theories, concepts and processes used in technology. The student is given technology related problems and is encouraged to use his/her own creativity in choosing the means at his/her disposal in which to solve these problems.
Twenty-first Century Lab - The twenty-first century lab is a highly computer-based curriculum which uses problem solving as its premier teaching method. The curriculum has been designed to increase computer literacy as well as stimulate creative thinking and problem solving abilities.

**Overview of Chapters**

Education as a whole is faced with the problem of stagnation and Industrial Arts/Technology Education are no exception. The world is changing so rapidly that it is passing by traditional educational curriculum in all disciplines. In Industrial Arts and Technology Education two philosophies and methods of instruction are being reviewed. This research has been made to compare these two approaches and show which is more appropriate to instruction needed to prepare our students for the future.

The following chapters will review the literature written by authorities in the field, presenting their feelings on the effectiveness of the two teaching methods. The methods and procedures used in the study will be discussed in Chapter III. The findings of the research study will be presented and explained in the text of Chapter IV. Chapter V of the study will include a summary of what was learned as a result of the research, conclusions that were drawn as a result of the findings and recommendations on how the research can be used to aid in our preparation of Technology Education for the future.
CHAPTER II
REVIEW OF LITERATURE
CHAPTER II
REVIEW OF LITERATURE

Chrysler Corporation President, Lee Iacocca, in a speech made to a group of American educators, expressed his concerns about the shortcomings of America's schools. He noted that, "our future doesn't depend on what top students can do, it depends on what average students can do, and our average students are falling behind." (Unger, 1984, p. 10). Throughout the past quarter of a century or more, answers to the problems, at the foundation of Mr. Iacocca's concerns, have been sought with little, if any, progress. Education as a whole has seemingly lost its focus on what its major objectives are or should be.

The push for "excellence in education" seems to be a step in the right direction; however, it is a slow process not without opposition. The major problem facing a reformation of a discipline is the actual commitment to a single, accepted philosophy which takes into account the future, guaranteeing its longevity. Industrial Arts is vulnerable to these problems.

In the Industrial Arts/Technology Education community, there are two major philosophical camps. The Industrial Arts camp is guided by a "project" philosophy which is very rapidly becoming a dinosaur in the educational community. Technology Education on the other hand has as its guiding light a problem solving philosophy applied to the systems of technology. In this chapter the two viewpoints will be discussed. The
discussion will include the comments, ideas and concerns of accepted authorities in the field of general and Technology Education.

**History**

The roots of Technology Education reach back as far as the vocational training received by members of ancient Egyptian and Babylonian society. Craft guilds supplied technical training during the transition from Medieval to Modern times in the fourteen and fifteenth centuries. The "father of manual training", Johann Heinrich Pestalozzi, originated Practical Arts, the direct ancestor of Industrial Arts in the late 1700's.

In the United States concern about a lack of skilled workers was recognized in a report made by the Douglas Commission of 1905. The commission found that the schools of the day were too literary oriented to prepare students for the "real world". In an attempt to remedy this problem the federal government mandated money for trade and industry and technical training in the Smith-Hughes Act of 1917.

In the late 1950's the United States found itself in a technological crisis. For the first time since the end of the Industrial Revolution, the U. S. found itself trailing another nation in technological strength. In 1963 the ramifications of this battle for technological supremacy led the United States Congress to pass a $60 million Vocational Education Act which carried Industrial Arts Education on its shirt tails.

At the beginning of the 1990's once again the United States finds itself in a technological crisis. With the surge for "excellence in education" we are finding that our schools are instituting "more required courses, stricter academic standards, and stronger disciplinary codes . . . clearly reminiscent
of recommendations offered nearly a quarter century ago . . . " (Bunting, 1987, p. 124). If history does indeed repeat itself this illustrates an excellent example. The call is not for a reform of old policies that do not work. It is for a new approach, a new philosophy.

"Project Based" Philosophy of Industrial Arts

In traditional Industrial Arts education, the emphasis has been very specific. The traditional approach focuses on manipulative skills necessary in the processes used in industry, the materials used and the step-by-step functioning of the individual throughout the processes (Johnson, 1989, p.9). This approach presents the student with specific procedures to follow in the obtaining of goals, with little if any input by the individual.

A curriculum based on the project approach as is exemplified by traditional programs is costly while offering little stimulation for the intellectual needs of its participants. In order to keep such a curriculum valid with today's ever changing technological society, equipment used in the teaching methods must be updated yearly. In a majority of actual situations, the work that is being done in traditional Industrial Arts programs dates between the 1930's and 1950's (Lauda, 1984, p.4).

Traditional programs include woodworking, metalworking, drafting and graphic arts. These programs are project oriented. They focus on the project as the goal to be obtained. The problems to be solved in industry, by the processes used, are not regarded as paramount as in the "problem solving" approach.
"Problem Solving" Philosophy of Technology Education

Where Industrial Arts Education is "project based", the new Technology Education philosophy is based on problem solving. These new classes emphasize a broad approach to technology. Through instruction and laboratory activities, Technology Education classes strive to stimulate creative and critical thinking in their student population (Johnson, 1989, p. 9). The major goal is to produce technically literate members of society.

Technology Education programs are broad based, meaning that the skills acquired are transferrable. The intuitive thinking skills that result from the participation in laboratory activities, can be applied in other technical situations whether they apply to other Technology Education programs, other school disciplines, on the job problems, or everyday situations that occur at home.

The use of machinery and tools and a grasp of the concepts related to the use of materials and processes remain important as they are in the traditional curriculum (Scarborough, 1989, p. 8). The student is presented with information on the use of the machines, tools, materials and processes associated with the problems to be solved. However, no set course is plotted for the student in the attaining the solutions. Through Technology Education the profession can move from ". . . instructing to questioning, from giving solutions to asking for new and innovative responses coming from students." (Anderson, 1989, p. 7). The new problem solving curriculum stimulates the students thinking and his/her feelings of self worth by allowing the student to "own" the solution to a problem (Stewart, 1989, p. 175).
Technology Education with problem solving as its driving force meets the needs of the individual. The solutions to the problems posed may have as many answers as there are people to answer them. Each student has a different capacity for problem solving. James Barnes (1989, p. 26-27), writes:

The problem solving method produces the best possible solution to a problem based upon the best judgement and decision making at a given moment in time. The problem solution is not exact, since many other solutions could be effective in solving the problem.

The Need for Change

In the early 1990's we are once again faced with a technological crisis similar to the one which ushered out the 1950's. Again education is in the spotlight as the number one suspect in the crime of an under skilled workforce. Unlike the problems which led to the Smith-Hughes legislation in the early 1900's, the problems are of a much broader nature. The problems we are presently being faced with are not about specific skills, rather, the failure of the system to produce functional members of a changing society.

As the great philosophers would analyze today, citizens are needed who can deliberate, who know both science and application, who can analyze technological systems and create and adjust these so that the current culture can be extended into the 21st century (Ritz, 1989, p. 9).

In 1983 the National Commission on Excellence in Education published a report titled "A Nation At Risk". In this report the commission describes a perilous decline in the economic, scientific, and technological productivity of the United States (Bunting, 1989, p.119). In times such as
these it is important to find a solution to the declining status of the nation before it is too late. In order for a student to fit into the future society that awaits him/her, he/she must have the ability to solve everyday problems. In a world that is changing as fast as ours this is no easy task. No longer can we take a project based approach, merely providing facts and steps to follow. "When one uses content to . . . teach students to develop skills so they are more employable, we are losing sight of our . . . mission" (Ritz, 1981, p.3).

Programs are needed that provide the students of today with the thinking skills of tomorrow. The old systems of feeding facts, memorizing and blindly following of procedures must give way to the new. If the students are to lead successful lives and our nation is to survive it is important that our work force be skilled self thinkers with understanding of the concepts that govern technology. Skills of this type will make it possible for the individual to understand the workings of the whole rather than just his/her little piece.

Summary

Problem solving as a focus of curriculum in Technology Education, is the change necessary in validating our profession as we approach the 21st century. It is neither a separate subject, nor solely part of science and technology curriculum (Sellwood, 1989, p. 3). Problem solving must be viewed as a necessary part of Technology Education if the profession is to keep up with the rate of technological developments. It will help produce members of society who can think for themselves, be easily trained in a number of different technical positions and are technically literate.
Taking all this into account, members of the profession must be prepared to give up the old ways of project based instruction. They must prepare to lead the way into the next century at the front of the wave of reform rather than the alternative of drowning in the sinking ship of an outdated philosophy. Put simply, Technology Education professionals must save their profession by making it applicable to the future and problem solving must be their tool.
CHAPTER III
METHODS AND PROCEDURES
CHAPTER III
METHODS AND PROCEDURES

Chapter III of this research paper has been included to introduce the reader to some important components involved in the study. The chapter will define and discuss the population studied, the instrument used, the procedures for implementing the instrument, procedures for treating gathered data, and the statistical analysis used. Ideally Chapter III will aid the reader in obtaining a clearer understanding of what actually took place throughout the research conducted.

Population

The target population of the study are male and female students of junior high school age (12 through 13) who have had experience in or are currently enrolled in programs in Industrial Arts or Technology Education. In order to make the study feasible, the students enrolled in seventh grade Technology Education from five Chesapeake junior high schools were used as a sample of the population. The students enrolled in three of these schools' programs (199 total) receive instruction characteristic of the traditional project based methods of Industrial Arts philosophy and the students of the other two schools' programs (99 total) receive instruction through problem solving methods.
The members of the sample population live in suburban and rural environments of southeastern Virginia. Low, middle and upper socioeconomic classes are represented in the research.

**Instrument**

The instrument used in gathering research data for this study is the "Cornell Critical Thinking Test, Level X" created by Robert H. Ennis and Jason Millman and published by Midwest Publications. The test was designed to examine an individual's ability to think critically and creatively. The test consists of seventy-one items and four sub-sections.

In the first section, the examinee reads a conclusion and decides which of several premises supports the conclusion. The second section measures the examinee's ability to judge the reliability of information. The third section tests the examinee's ability to judge whether a statement follows from premises. The fourth section involves the identification of assumptions. (Ennis, 1985)

**Classroom Procedure**

Each teacher of the junior high school classes involved in the research was given the appropriate number of tests to be distributed to his/her students. Along with the tests, each teacher was given instructions on how the tests were to be administered, to assure continuity throughout the testing of the five schools.

The "Cornell Critical Thinking Test" was given to each member of the Technology Education classes of the five schools. Each teacher monitoring the classes during testing was set in a role as proctor of the test and was not allowed to aid the students in any way during the examination. The testing
was conducted May 13 through 25, 1990. On completion of the testing, the tests were grouped by school, scored and recorded.

**Procedure for Treating Data**

Once the scores for each test had been calculated, the tests were grouped according to the method of teaching the curriculum. The 199 test scores from the three junior high schools using the traditional method of instruction were grouped together as one group. The two other schools', which use the problem solving approach to teaching, 99 scores were grouped as the other.

**Statistical Analysis**

The research data gathered from the testing of the five schools was divided as to the methods of instruction and subsequently placed in two groups of scores. The two sets of scores were then compared using the "t-test" method of statistical analysis.

The mean of each set of scores was figured by dividing the sum of the scores by the number of scores for the group. Upon finding the mean score for each group, the difference of each score from the mean was calculated. The difference from the mean for each score was then squared and added to the other squared differences to calculate the squared sum of differences. When the preceding had been calculated, the numbers obtained were then substituted into the formula for t-test statistical analysis. The results and findings will be discussed in Chapter IV of the research study.
Summary

The instrument used for the research, the "Cornell Critical Thinking Test", will help determine the critical thinking and creative abilities of the students tested. Using the results of the test, it may be determined which of the two groups tested have greater abilities in these areas.

Once it has been determined, whether or not the group instructed using problem solving methods shows a greater ability in the area of critical or creative thinking, conclusions can be drawn. In Chapter IV of this study the test scores and research findings will be presented.
CHAPTER IV
FINDINGS

The purpose of this chapter is to introduce the findings of the research study. The study's purpose, to test the creative and critical thinking ability of the students in traditional and innovative programs, was accomplished by using a published test.

The research instrument used was "The Cornell Critical Thinking Test, Level X". The test was designed for grade levels 4 through 14. The instrument's 76 items are divided into four sections. Part one of the test is designed to examine the student's ability to judge whether or not a fact presented supports a hypothesis; part two examines the student's ability to judge the credibility of observation reports; part three examines the student's ability to decide what follows an event; and finally, part four tests the student's ability to judge what is assumed in an argument.

"The Cornell Critical Thinking Test, Level X" was administered by the teachers of each class of seventh grade Technology Education at the five junior high schools. The scores obtained from the testing will be reported and compared in the following chapter.

Reporting of Data

Figure 1 is a bar graph showing the mean scores of the students from the five schools as recorded and divided by school. The two schools representing the problem solving philosophy, Western Branch and Crestwood, though more consistent than the schools from the traditional philosophy fall short of the scores from Great Bridge Junior High.
The total scores of students from the traditional programs are presented in Figure 2. Figure 2 shows the scores achieved by the students from the traditional programs and their relationship to the amount of students achieving particular scores.
Figure 2 Total Scores of Students from Traditional Philosophy Programs

Figure 3 is a bar graph designed to illustrate the relationship of scores and numbers of students achieving them in the "problem solving" based programs of the new Technology Education programs.

Figure 3 Total Scores of Students from "Problem Solving Based" Programs

Figure 4 is a bar graph designed to show the relationship between the scores achieved by the two different programs. The horizontal axis of the
graph shows the scores achieved while the vertical axis shows the percentage of students that achieved them from each program.

![Comparison of Scores](image)

**Figure 4 Comparison of Scores**

**Statistical T-test Figures**

In order to effectively compare the scores from the two groups of students, the traditional programs' scores were grouped together and the mean score was found and compared to the total mean score of the new programs using the statistical $t$-test method. The resulting calculation from the $t$-test was a -.925. This number shows a level of significance of approximately .17 or an 83% of the same results occurring in a similar test. (This number is an estimated value found by calculations compared to The Oliver and Boyd Table II Critical Values of $t^*$.)

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Summary

The findings of the research study, obtained by the comparison of test scores from the two groups, have been presented in this chapter. In Chapter Five of this study the research will be summarized, a conclusion of the data gathered will be presented and a recommendation of how the research can be valuable will be discussed.
CHAPTER V

SUMMARY, CONCLUSION
AND RECOMMENDATIONS
CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATIONS

The problem of this study was to compare traditional Industrial Arts and new Technology Education instructional methods and their affects on the problem solving abilities of the students within these programs. This chapter will summarize the proceeding chapters, offer conclusions based on the findings of the research and present recommendations as to how the study can be useful to future studies.

Summary

This research study has presented a problem that is a valid one in all Technology Education circles. The field is witnessing some very important changes in the world from which it takes it subject matter. In order to keep pace with this every changing society, programs in Technology Education must change appropriately. It has been the focus of this study to determine whether or not one of these innovations is headed in the right direction.

The research instrument was administered to the five schools to help determine whether or not the new programs in Technology Education are effecting the creative and critical thinking abilities of its students. The importance of these abilities is apparent in much research and educational literature, where it is being made quite clear that the search is toward a means of producing functional members of society that can think for themselves.
In Chapter IV, Findings, of this research study, the actual figures from the data gathered were presented. These figures showed a strong consistency between the two schools using the problem solving approach to instruction. The schools from the traditional programs showed a difference of 19 points between the top and bottom scores. The surprising part of the research was that when the data was categorized by school, the scores from a traditional program were the highest at a mean score of 51.

Conclusion

The hypothesis as stated in Chapter I of this study is as follows:

The research contained in this study will demonstrate that the innovative approach to problem solving in education, characteristic of the "new" Technology Education programs, is more effective in stimulating students' creativity and decision-making ability than is traditional Industrial Arts instruction.

As a whole the problem solving programs did score higher than their traditional counterparts on the "Cornell Critical Thinking Test", showing some support for the hypothesis, however; the level of significance, as determined by the statistical t-test was considerably lower than anticipated and too low for the hypothesis to be accepted.

The fact that there was no way of determining the creative thinking abilities of the members of the test population prior to their experiences in the programs could be considered a contributing factor in the rejection of the hypothesis. Another such factor could be the question of whether or not the "Cornell Critical Thinking Test" is an appropriate test to determine creative thinking abilities stimulated by the new problem solving programs in question.
Recommendations

It is evident when reading this research study and examining its findings that the ideal situation, of a perfect program in Technology Education which produces students with impeccable powers of creative thinking, was not found to exist, or at least not yet. The following are a few recommendations that should be reviewed by those interested in conducting follow up studies or considering improvements to the present curriculum in Technology Education programs.

- All students entering Technology Education programs should be given some form of problem solving, creative thinking and critical thinking pre-test to determine these levels when entering the course of study. This will help provide researchers and curriculum writers with a base of comparison to help determine the effectiveness of their programs.

- It is apparent that the curriculum of the present Technology Education programs in the junior high schools studied are not as effective in stimulating creative thinking abilities as they should be. A review should be made of the present curriculum to determine what should be changed to more sufficiently meet the needs of their students.

- Finally, a test should be designed specifically for the purpose of testing the problem solving abilities of students.
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