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A Study to Determine the Relationships Between a Local School Division's Middle School System's Technology, Science, and Mathematics Course Curricula and the Accommodation of State and National Goals, Standards or Objectives

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**A STUDY TO DETERMINE THE RELATIONSHIPS BETWEEN A
LOCAL SCHOOL DIVISION'S MIDDLE SCHOOL SYSTEM'S
TECHNOLOGY, SCIENCE, AND MATHEMATICS COURSE CURRICULA
AND THE ACCOMMODATION OF
STATE AND NATIONAL GOALS, STANDARDS OR OBJECTIVES**

**A Research Paper
Presented to the Graduate Faculty
of the Darden College of Education
at Old Dominion University**

**In Partial Fulfillment
of the Requirements for
the Master of Science in Education Degree**

APPROVAL PAGE

This research paper was prepared by William C. Reed under the direction of Dr. E. M. Rudisill in ECI 636, Problems in Education. It was submitted to the Graduate Program Director as partial fulfillment of the requirements for the Degree of Master of Science of Education.

APPROVAL BY:

Dr. E. M. Rudisill,
Advisor and Graduate
Program Director

Date

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William C. Reed

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CHAPTER I

INTRODUCTION

Succinctly stated in *A Nation at Risk: The Imperative for Educational Reform*, in 1983, our nation, largely clinging to concepts of a past in which we, as a nation, were unchallenged and preeminent, had to consider the measures necessary to remain competitive in a changing world (LaPorte & Sanders, 1993, p. 17; Dugger, 1994, p. 20). The reports that followed, from each respective discipline, reflected similarly grave perspectives. Many communities discussed the pros and cons of various approaches to reform. Technology was added to list of formal disciplines to be taught though it was initially a repackaging of industrial arts (Dugger, 1994, p. 20). Though not a new concept, the need for some form of coordination or integration of technology, science, and mathematics was considered (LaPorte & Sanders, 1993, p. 17). The recommended degree of coordination or integration of the component disciplines has varied from maintaining each individual discipline's uniqueness, as reported by the National Research Council's National Committee for Science Education Standards and Assessment National Research (Dugger, 1994, pp. 20-21), to a two discipline integration, such as mathematics and science (Underhill, Abdi, and Peters, 1994, p. 26), to a grade school's "thematic approach" in which all disciplines are taught in conjunction with and context of a project (Dugger, 1994, p. 21).

The need to consider alternative approaches to integration or coordination for technology, science and mathematics is currently being explored through two research efforts at the middle school level (Dugger, 1994, p. 21; LaPorte & Sanders, 1993, p. 18).

Sponsored by the National Science Foundation, the **Technology, Science and Mathematics Integration Project** is intended to explore the combination of disciplines (LaPorte & Sanders, 1994, p. 18) in a fashion that takes advantage of their symbiotic nature and relationships (Dugger, 1994, p. 7). Another alternative would approach the problem from the engineering and technology perspective by looking at the required disciplines, the systems and processes involved, and the potential impact of the effort (Bensen & Bensen, 1993, pp. 4-5). An intriguing idea, it has not yet been endorsed by others involved in the integration reform debate.

One of two **Technology, Science, and Mathematics Integration Project** research efforts is being conducted in Virginia by the staff of Virginia Tech. The criteria for the Virginia project attempts to require no major structural changes or behavior modifications in the teachers available. Findings revealed, thus far, have indicated some relatively tragic impediments such as the "elective" nature of technology education, the lack of correlation or coordination between technology, science and mathematics curricula, the continued segregation of disciplines, and the systematic elimination of technology educators from middle school teaching teams (LaPorte & Sanders, 1993, pp. 18-19).

In consideration of a fully integrated curricula that might, someday, systematically remove omissions or errors, the American Association for the Advancement of Science has offered proposals that would more closely coordinate the relationships between each discipline's respective educational objectives (*Benchmarks for Science Literacy*, 1993, p. 3). In the interim, a series of activities that coordinate the lessons of technology, science,

and mathematics have been proposed (LaPorte & Sanders, 1993, pp. 19-20).

In the absence of a detailed reform of curricula, the adherence to established standard learning objectives, teaching of related skills and concepts, re-enforcement of cross-content, problem-solving methods and skills, broadened qualifications of teachers through programmatic or in-service reforms, and more alert interaction undertaken by each individual school and its teaching staff could make a difference in the near term. Questions to be asked locally include: Do we comply or attempt to comply with existent standards? Does the state, school division, school, and teacher agree with and accept the need for the changes required? In the spirit of integration or coordination, are efforts to conduct in-school, teaching team coordination underway or practiced?

The concept of coordinating technology, science and mathematics curricula is important to the future. Though there have been ongoing efforts to accomplish the goals, are the successes seen limited to the observation of a few stellar examples of meeting a need while the mainstream curricula and attitudes remain largely unchanged? Whether the concept is too new or lacks sufficient support, the pulse of the technology, science and mathematics integration or coordination effort in the mainstream has not been taken. Such is the nature of this study.

Statement of the Problem

The problem of this study was to determine the relationships between a local school division's middle school system's technology, science, and mathematics course curricula and the accommodation of state and national goals, standards or objectives.

Research Goals

The goals of the study were to determine if:

1. A state's learning standards, for this study the Virginia Standards of Learning, acknowledged, accommodated, or complied with national goals, objectives, or recommendations for technology, science, and mathematics curricula at the middle school level as set forth in a published, national level coordination/integration standard;
2. A local school division's curricula, for this study the Virginia Beach City Public School's middle school technology, science and mathematics curricula, complied with the established state standards (Virginia's Standards of Learning); and
3. The Virginia Beach City Public School's middle school technology, science and mathematics curricula were related, associated, coordinated or integrated in any fashion.

Background and Significance

Observation of present day mathematics, science, and technology classes in a typical Virginia Beach middle school can cause the observer to come away with many feelings, not all of which are positive. Two of those recently considered were that: (1) mathematics, science, and technology classes are planned and taught independently of one another, and that (2) there was little, if any, acknowledgment or support of what was being taught elsewhere in the school by each discipline. These observations apparently

represent a "general condition" in the middle schools of Virginia as pointed out by LaPorte and Sanders (LaPorte & Sanders, 1993, pp. 18-19). When viewing the classes at any specific grade-level, the missed, wasted, or overlapping opportunities for cross-curricula teaching, interdisciplinary re-enforcement, and greater student association and learning were numerous. The observations did not appear to conform with the enlightened trends of integration or coordination commonly accepted by educational leaders at the national or state levels or findings and recommendations frequently discussed in professional journals. Student interests, skills preparation for the inevitable workplace and a career, whether via technical training or college, and efficacy of education dollars would suggest that the educational leadership's perspective of integrated or coordinated approaches are valid. Implementation of the Technology, Science and Mathematics integration movement may be too new but does need an initial or renewed consideration.

If the nationally acknowledged effort to integrate technology, science and mathematics education, as espoused by PROJECT 2061, the Technology, Science and Mathematics (T/S/M) Integration Project, and other less recognized projects is believed to be capable of achieving the desired improvement in national academic and economic performance, then compliance with the spirit of the goals and, if available, implementation of those standards, on a nation-wide basis, is required before any appreciable change can be expected. While consensus on the best course of action may be achievable in the conference rooms of legislative bodies and within panels of educational and commercial leaders, until they are realized in classrooms and students' minds, they are just ideas. To be fair, the results of yardstick measurements cannot be attributed to any one effort

without knowing what is being taught and practiced. The results of this study, in some small way, provide a snapshot of implementation: Is the concept moving toward implementation and fruition? If it is, what can be done to refine it? If not, what can be done to speed it on its way and at what level? Can in-service teacher education make a near term improvement while awaiting for more formal curricular changes? In light of budgetary cuts to education, can the goal still be achieved?

Limitations

The potential of this study is easily overwhelming as the mathematics, science, and technology concept touches each level of public education from the emerging guides for integrated curricula, at the national level, to the implementation guidelines directed by various standards of learning, in different states, to the curricula guides promulgated by an even greater number of school divisions, and, finally, as implemented by different teachers within each school. This endeavor is an initial, logical stage study with potential for a much broader examination of compliance and recommendations for success. Since there are ongoing projects in Virginia, at the middle school level, constraints of one state, one school division, and one middle school are achievable and reasonable.

The references on the subject are reasonably available. There are documents available at national, state, and school division levels and are in the forms of goals, standards, or objectives if not curricula. Articles applicable to the field of study are limited in their depth and do not report prior examinations of general accomplishment.

The study is limited to the review, comparison, and interpretation of available

public education documents.

Assumptions

The researcher had little prior experience with the formal educational aspects of this study and integration or coordination of curricula. Workplace experiences with engineering, applied science, supporting mathematics, and the need to be innovative in creating solutions to existent problems has, however, formulated an opinion that finds resonance in the integrated or coordinated curricula approach in these disciplines.

Mathematics, science, engineering, and technology are best taught from a coordinated or integrated base which fully embraces the ultimate relationship of the respective disciplines and provides the simultaneous consideration of the conceptual and the applied.

National standards, goals or objectives have been developed for integrated or coordinated teaching of mathematics, science and technology at all levels kindergarten through grade 12 by one or more organizations.

States have ongoing programs to revise standards for learning and objectives, as required and, in fact, extended the timeframe of this study due to a standards' revision which occurred shortly after this study was undertaken.

State approved curricula are available to respective school divisions.

School divisions have implemented some or all of state approved curricula.

Local school staff efforts have not moved toward preparation for, or integration of coordinated or integrated technology, science, and mathematics curricula.

The nature of this study could be viewed as hostile from a school division's, school's or staff's point of view.

Procedures

The initial review of literature attempted to highlight points of interest, identify goals, objectives, standards, and curricula, and discover appropriate assessment methodology for the study. State standards were obtained from public sources and agencies, were confirmed as currently valid after delays for revision, while efforts to obtain draft revisions were fruitless. Draft revisions were not released. For the sake of accuracy, this study waited for finalized state revisions. School division objectives, curricula or guides were obtained from the school division's central office and a cooperating middle school after appropriate revisions were promulgated.

An administrative comparison of published goals, objectives, standards and curricula was the initial step. Follow-up interviews with school division mathematics, science and technology leaders, and school mathematics, science and technology teachers would be the next, appropriate step but were considered to be beyond the scope of this study.

Results of comparisons have been tabulated, analyzed and interpreted.

Definition of Terms

The following terms are used in this paper and provided as a quick reference to possibly unique vocabulary.

AAAS	American Association for the Advancement of Science
ABET	Accreditation Board for Engineering Technology
curriculum	"planned by teachers, approved by administrators, delivered by teachers, and experienced by students; an overview of the scope and sequence of student experiences; a detailed delineation of learning experiences" (<i>Benchmarks for Science Literacy</i> , 1993, p. 318).
engineering	a profession in which knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgement to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind.
interdisciplinary	"With relation to curriculum, this term is used to refer to many different possibilities, from mere "coordination" among several disciplines, to courses made up of still-identifiable chunk of two or more disciplines (as in many general science courses), to courses that are integrated around topics and issues that cut across many disciplines" (<i>Benchmarks for Science Literacy</i> , 1993, p. 320).
ITEA	International Technology Education Association
mathematics	a study of all conceivable abstract patterns and relationships.
NCSESA	National Committee for Science Education Standards and Assessment
NCTM	National Council of Teachers of Mathematics
NRC	National Research Council
NSTA	National Science Teachers Association
science	a study of our natural world and universe.
SFAA	Science for All Americans

strawman	a document offered to elicit comment and dialogue.
S/T/S	Science, Technology, and Society
technology	a study of our human created and controlled world.
T/S/M	Technology, Science and Mathematics Integration Project

Overview of Chapters

Chapter I frames the problem addressed by this study to include the significance that an integrated or coordinated T/S/M education has at the national level including a brief history of how such a sweeping concept of reform came to be. The relative age of the T/S/M integration effort would suggest or indicate that its implementation efforts are behind many other education reforms, may be faced with budgetary limitations, and have not yet been realized at the student level. The observed "lack" of integration, coordination, or even knowledgeable staff motivated this study and might provides a snapshot on the road to new successes. The age of the topic, the widespread need for such an assessment, and lack of published information on the subjects are clear limitations but also incentives. It has been assumed the integrated T/S/M curricula is the "right" course of action while the nature of this study may illicit hostility from the observed school division and school. Procedures for obtaining the needed documents and clarifying the findings have been alluded to above including procedures for clarification, determining intentions and staff interviews.

The remainder of this study will attempt to lay out current thinking on the subject of integrated T/S/M curricula and its advisability; detail procedures for the curricula-

standards review and interviews; and detail data collected and analyzed, observations made, and recommendations for relatively immediate improvement, if any.

Chapter II will provide a review of the available literature concerning the zero-based review of integrated curriculum, the foundations on which it might be based and results of some initial efforts. Chapter III will briefly discuss the procedures used to trace the continuity of compliance, adherence, or agreement from national educational leadership to middle school student's level. Further, the methods used to clarify the local attitudes and concomitant state of implementation will be specified. Chapter IV will state the findings of this project. Chapter V will draw conclusions and make recommendations for local achievement of the goals considered significant and worthwhile.

CHAPTER II

REVIEW OF LITERATURE

Literature discussing the need for educational reform spans many decades and is comprised of a vast and constant stream of studies, opinions and proposals that vary in substance, content, orientation, and methodology, a fact to which the bibliography can attest. The simple salient points, common to them all, state that comprehensive reform is a necessity, and that it will be a difficult task. Assuming that reform is necessary, choosing the right path, the "right stuff", then becomes the challenge and is where a myriad of projects are mired. What is the "right stuff"? For the purposes of this study, those references dealing with bases other than technology, science and mathematics, their impact on society, and the environment have been set aside thus substantially reducing the field. Key descriptors include interdisciplinary or integrated curricula and impediments to progress.

Interdisciplinary or Integrated Curricula

General consensus indicates that the need for a systemic reform of the American education system is vital to achieve the desired skills required of an informed citizenry in the next century (Anderson et al, 1990, p. 4; and *Benchmarks for Science Literacy, 1993, p. 323*). It is also consensual that those plans should consider a comprehensive, 'across the disciplines' approach (*Science for All Americans, 1990, pp. 213-214; Benchmarks for Science Literacy, 1993, p. 320; and Dugger, 1994, pp. 21-22*). In addition, teachers must

be better trained and empowered (Anderson et al, 1990, pp. 4-5; and Dugger, 1994, p. 22), and there must be a change in the culture of schools (Anderson et al, 1990, p. 5).

In the most recent generation of articles, the authors' backgrounds generally serve as the foundation on which their reforms would be based. Some examples are:

"As a result, technology educators will need to incorporate scientific and mathematical principles into their curricula" (LaPorte & Sanders, 1993, p. 17).

"For its part, science education - meaning education in science, mathematics and technology - should help students to develop the understandings and habits of mind they need to become compassionate human beings able to think for themselves and to face life head on" (*Science for All Americans*, 1990, p. xiii).

Despite contention over which discipline would best serve as the foundation, several common, non-disciplinary 'pillars' emerge from most of the literature. Included are: knowledge of a subject, inter-disciplinary linkage, social responsibility, and development of thought processes and methods. It is in the area of thought processes and methods development, referred to as "learning to think" or "thinking skills" (Anderson et al, 1990, pp. 2, 7 and 11-18), "developing understanding " (Dugger, 1994, p. 21), or "habits of the mind" (*Science for All Americans*, 1990, p. xiv; and *Benchmarks for Science Literacy*, 1993, p. 319), that a true educational goal is established.

In the areas of concern to this study, both SFAA and T/S/M efforts cite science and technology as cornerstones. In the disciplines, the thinking skills historically associated with them are almost more important than the content itself. They are:

- (1) From science, scientific method - a logical method or process for proceeding and an unbiased interest in the fair collection, interpretation, and comprehension of

observed events in order to understand true causes and effects (Dugger, 1994, pp.5-6 and *Benchmarks for Science Literacy*, 1993, p. 9); and,

(2) From engineering and technology, a systems approach - the way in which things operate as parts of a system which may have influence or manifest effects in other systems (*Science for All Americans*, 1990, p. xiv).

Unfortunately, these skills are not taught overtly nor independently from the parent subject. These skills are mastered only by the few, abnormally perceptive adolescents and will be of note only when assessed as part of the parent subject. For the remainder of those who will eventually acquire the skills, experience and further education are required to clarify them as processes independent from the parent and have interdisciplinary applicability.

Within the search for integrated, interdisciplinary curricula, a popular slogan is, "Less is more." Essentially, the change from rote learning to thought processes and understanding requires the sum of information covered to be limited to specific topics, possibly along themes, that are explored in more depth and with an emphasis on process (*Benchmarks for Science Literacy*, 1993, pp. 320-321; and Anderson et al, 1990, p. 2).

Social responsibility depends on each individual's value system. That value system's development, typically considered in a realm other than public education, may be tangentially influenced by those inspired or charismatic educators with a global effect on their students.

The recognition of the need for interdisciplinary, integrated curricula and the focus on thinking skills are significant steps in the right direction. Integrated or coordinated

curricula must assume a basis. The semantics of this issue are germane to the state or potential of implementing a multi-disciplined approach to literacy or skill building in the areas of science, mathematics and technology. To achieve consistency throughout a nation, there must be nationally recognized goals, standards or objectives which can be expanded into learning objectives that, in turn, can be further expanded into lesson plans that ultimately deposit the desired skills and knowledge in each student. Hopefully, some of those students will, someday, realize the goal, standard or objective on behalf of her/his society.

To that end, the SFAA, T/S/M, and S/T/S approaches seem to have good support, though none have curricula actually developed supporting their perspective. The progress each has made toward developing required curricula may be the measure of their future adoption and success in implementation.

While there are volumes written about the S/T/S approach, the equivocation over what is to be included and what is not seems to have slowed development. The societal aspects of the S/T/S approach are easily suborned by the other efforts.

The T/S/M concept is at the root of a popular technology based approach, but as a movement, is not well defined. There are some thematic projects that have been developed and have been very successful (LaPorte & Sanders, 1993, pp. 19-21 and Dugger, 1994, pp. 21-22). They have been products produced responsive to a need and may be viewed as lacking the formal basis typically associated with the more established science and mathematics community solutions. The T/S/M project may also stand in less prominence, as one author put it, because there are few technology champions and that

the stigma of "vocational or industrial arts" is still so pervasive as to prevent a full partnership (Bensen & Bensen, 1993, p. 3).

Only in the realm of the American Association for the Advancement of Science's Project 2061 and its *Benchmarks for Science Literacy* has substantial, in-depth, formal work been done, to date, on establishing well thought out, fundamental goals, standards or objectives in a published format. The *Benchmarks* are a substantial compendium of coordinated or potentially integrate-able goals from which learning objects should be written. In fact, the National Academy of Sciences' National Research Council recently stated their endorsement in the introduction to their draft *National Science Education Standards*:

"The National Research Council of the National Academy of Sciences gratefully acknowledges its indebtedness to the seminal work by the American Association for the Advancement of Science's Project 2061 and believes that the use of *Benchmarks for Science Literacy* by state framework committees, school and school district curriculum committees, and developers of instructional and assessment materials complies fully with the spirit of the content standards presented in this draft" (*National Science Education Standards* - draft, 1994, pp. 1-2).

It is noted that additional efforts on establishing standards are being undertaken such as those in the "Technology for All Americans" in which the National Science Foundation is supporting an effort to formulate technology standards (Dugger, 1995, pp. 1-2).

Thus, many years of effort have been reduced and endorsed by one of the three community factions. Technology and mathematics communities are yet to be heard from on a formal scale of goals, standards or objectives.

It is unfortunate that the "strawman" approach cannot be adopted in which technology and mathematics communities consider what has been offered by the *Benchmarks*. By using it as a draft to consider and modify, it could be the basis for speeding a nationally accepted, interdisciplinary, integrated curricula along.

It is curious that authors in either science or technology communities seldom acknowledge the other's efforts. It is the contention of some in the technology community that the lack of acknowledgment is based on a lack of respect and acceptance (Bensen & Bensen, 1993, p. 3). The mathematics community seems to be on middle ground and identifies their goals as adjuncts to either of the others. Considering the state of, or better, lack of interdisciplinary cooperation or acknowledgment, consensus on an integrated technology, science, and mathematics curricula standard would seem to be far off. If there is to be fully integrated, interdisciplinary curricula in science, mathematics and technology, mutual respect must offered and accepted by all involved.

Impediments to Progress

As discussed in all credible literature, there are impediments to progress more profound than the perceived disagreement within the education community.

Interdisciplinary consensus exists on this point.

Consensus on content and approach (discussed above), beliefs and values to be included, how broad reaching the reforms are to be, who is to be educated, and the collaborative effort needed to accomplish such a reform is a necessary requirement. The possibility of achieving a consensus on so broad of a range of topics and their adoption as

a national standard seems doubtful (*Science for All Americans*, 1990, pp. 212-215 and Anderson et al, 1990, p. 3).

The time and resources required to implement a reform as sweeping, as discussed in the literature, into the American education system will be quite a substantial investment. If a national standard of integrated curricula were adopted, the development as state objectives thence local curricula and lesson plans for some 20,000 educational divisions, from kindergarten to university levels, will take decades. That schedule of milestones assumes there is a will to do so (*Science for All Americans*, 1990, pp 210-212).

The development and production of adequate teaching materials, such as textbooks and teaching guides, is a major stumbling block. Lesser efforts by national organizations such as the AAAS, NSTA, and NCTM have been costly in time and resources and are then subject to acceptance and monetary considerations. Wealthier school divisions may be able to comply with the plan within a reasonable period of time, but poorer divisions will be no more able to comply, due to financial constraints, than they are when trying to update outdated materials (Anderson et al, 1990, p. 4).

The preparation of the teacher base, especially when such a substantial of a change is required, again takes time and resources as well as institutions capable of accomplishing the task (*Science for All Americans*, 1990, pp 212-213). Even the preparation of a new teaching pool does not guarantee that all current teachers and administrators will be supportive of such sweeping changes (Anderson et al, 1990, p. 3).

Change is usually not accepted by parents who have expectations linked to milestones such as SATs. "Will the new program improve the potential?" is a reasonable

question.

The expectations of students is the final stumbling block to achieving student learning objectives (Anderson et al, 1990, pp. 3-4). Change causes even a more profound effect in the young. Unless implemented from kindergarten forward, student resistance would be enough to cause failure.

All aspects considered, it would seem that the concepts represented by SFAA and T/S/M efforts are laced with many negative factors. A yet undefined strategy seems to be required to achieve the concepts championed by the SFAA and T/S/M programs.

Summary

The review of literature revealed a wealth of ideas for significant improvement to the educational process within the United States, especially in the fields of technology, science and mathematics. The interdisciplinary, integrated curricula movement is consensual, in principle, but the basis - i.e., science or technology - for such change is not generally accepted. The *defacto* standards offered by the AAAS's Project 2061's effort, *Benchmarks for Science Literacy*, does serve as an existent basis accepted by at least the science community. There is brief acknowledgment by some technology authors. Despite the many positive aspects of the interdisciplinary, integrated curricula movement, the impediments or stumbling blocks to general progress are substantial if not impossible, especially during times of governmental financial cuts. Alternatives exist, such as intervention of the industrial community, though highly unlikely. Other strategies for implementation, void of the "not invented in our community" syndrome are required.

CHAPTER III

METHODS AND PROCEDURES

The nature of this research project was to compare the published goals, guidelines, standards, or objectives for technology, science and mathematics education existent at national, state and local levels and to determine whether there was a degree of incorporation, integration, or coordination evident at various levels, most particularly at the local level. This chapter briefly describes the "standards" to be compared, the methods used to compare the "standards," the methodology used for determining correlation of the included goals, guidelines, standards or objectives, the statistical analysis applied, and a chapter summary.

Data Reviewed

Data, comprising the primary feature of this study, were:

- A. A *defacto*, national standard containing goals, guidelines, standards or objectives for an integrated or coordinated science, mathematics and technology curricula. The document chosen, the American Association for the Advancement of Science's *Benchmarks for Science Literacy*, was believed to be a unique document at the time of this study. Only materials listed for grades 6 through 8 were considered.
- B. At the state level, the Commonwealth of Virginia's *Standards of Learning for Virginia Public Schools* for Science and Mathematics and the

Technology Education Instructional Tasks and Competencies for middle school technology.

- C. At the local school division level, the Virginia Beach City Public School's *Curriculum Guides* and included learning objectives for middle school science, mathematics, and technology.

Methods of Data Collection

The documents chosen for comparison were assembled directly from the respective organization. The *Benchmarks for Science Literacy* were obtained from the American Association for the Advancement of Science, the *Standards of Learning for Virginia Public Schools* from the Commonwealth of Virginia Department of Education, and the various curriculum guides through the Virginia Beach City Public School's Department of Curriculum and Instructional Services. A breakdown of the standards databases used are provided in Chapter IV and Addendum A to this paper.

Description of Research Methodology

National, state and local goals, guidelines, standards, or objectives were rendered, by scanning or direct access from magnetic media, into nine databases. The data files were reformatted into a consistent form in which level (national, state, and local), discipline (technology, mathematics, and science) identity, and referenced document article and page numbers were maintained. The nine resultant 'cells' were identified as follows: BMM, BMS, and BMT for *Benchmark* mathematics, science, and technology; VAM,

VAS, and VAT for Virginia *Standard of Learning* mathematics, science, and technology; and VBM, VBS, and VBT for Virginia Beach *Curriculum Guide* mathematics, science, technology.

The concept of identifying a word or phrase that constituted a strand of knowledge with potential applicability to all three academic disciplines was adopted. A strand search word or phrase list was devised from the textual, discussion portions of the chosen standards' documents when no such list of commonly held words could be identified. 555 words or phrases resulted. The list can be found in Appendix A to this paper as well as Addendum B.

A search engine was devised that permitted each database cell to be searched for the selected strand words or phrases. A match resulted in a listing which included cell identity, article reference number, a page number for ease of access to the original text, and an excerpt from the referenced article which would permit the researcher to make a determination of contextual usage. The listing can be found in Addendum C to this paper.

A second search engine was used to acquire cell by cell statistics for each search strand word or phrase. Simple counts and percentages were calculated.

From the listings produced and the original texts, the researcher would then evaluate the contextual usage of each search strand word or phrase in those excerpts, and if necessary, original texts listed. The primary interest was in the similarity of word or phrase usage, including semantical variations. A similar use in two or more cells resulted in a 'contextual correlation' as follows:

- A. Complete correlation - all levels and all disciplines used the word or phrase

in the same manner which would be interpreted as seeking the same educational goal.

- B. General correlation - all levels in at least one discipline used the word or phrase in the same manner which would be interpreted as seeking the same educational goal.
- C. Partial correlation - usage of the word or phrase occurred at two levels in any discipline or in all three disciplines at one level in the same manner which would be interpreted as seeking the same educational goal. Partial correlation resulted in six sub-groups: national and state, national and local, state and local, national, state, and local, respectively. It was considered possible for a word or phrase to have general correlation in one or more usages and to have partial correlation in other usages.

A determination of non-correlation was made if one of the following determinations was made:

- A. Single entry - the search word or phrase was found once in all nine databases. A single entry would be considered non-comparable or correlated.
- B. Same cell - the search word or phrase was found multiple times but all occurrences were in the same cell. This would indicate a unique usage by the authors of the cell either along disciplinary or institutional lines. Such words were to be considered not comparable to other cells and non-correlated.

- C. General - the search word or strand was found to be used in a contextually different or unique ways.

The final category, no entries, would be considered. Despite usage in general discussions within the reference, some words may not have been used in any of the nine databases applicable to middle school curricula.

The researcher's evaluation would be recorded with word occurrence counts and percentages. This information can be found in Addendum D to this paper. A summary of those evaluations can be found in Chapter IV and Addendum E to this paper.

Statistical Analysis

The number of occurrences of each search strand word or phrase and percentage per cell, were calculated. A summary of matches and words used in each cell will be developed. A distribution by the number of matches per word will be determined and divided in to ten intervals. Mean, mode, median and standard deviation will be calculated for the match distribution. The number of contextual correlations or non-correlations will be calculated based on evaluation data. An attempt will be made to determine a degree of correlation by standards level, i.e., national, state, or local. The possibility that words will be used uniquely, based on cell, level or discipline, will also be considered. More complex statistical analysis methods were considered but would contribute little to a final determination of whether the local curricula guides implement national and state standards..

Summary

In this chapter, a brief description of the national, state, and local goals, guidelines, standards or objectives was provided, the method of compiling those published goals, guidelines, standards or objectives existent at national, state and local levels were mentioned, the research methodology was described, the criterion for determining correlation was defined, and statistical measures were discussed. In the following chapters, the results of comparison will be presented for analysis and a determination of the achievement or non-achievement of integration or coordination goals in a local division's curricula will be made.

CHAPTER IV

FINDINGS

The compendium of information considered in this study, though restricted to only middle school standards, was immense. The resultant comparison listings for correlational consideration were even more voluminous. For that reason, the presentation of data provided in this chapter will be restricted to only samples of the resultant data listings, summaries of the results of the analysis of data, and summaries of the correlational data derived. Complete listings of intermediate documents are found in the Addenda to this paper. The chapter will end with a summary.

PRESENTATION OF DATA

Correlational data was derived from databases constructed from *Benchmarks for Science Literacy*, *Standards of Learning for Virginia Public Schools*, and various Curriculum Guides used by the Virginia Beach City Public Schools. The databases constructed and their content were distributed as depicted in the Table 1.

	Mathematics	Science	Technology	Level totals
American Association for the Advancement of Science's Benchmarks for Science Literacy	79	165	108	352
Virginia's Standards of Learning	121	184	1163	1468
Virginia Beach City Public Schools' Learning Objectives	1740	362	561	2663
Discipline totals	1940	711	1832	4483

Table 1 - Summary of articles contained in the databases derived.

The search strand word or phrase list was derived from the discussion portions of the texts of the standards used. The Search Strand Word or Phrase List can be found in Appendix A. There were 535 words and 20 phrases considered appropriate. Hereafter, these words will be referred to as elements of the search strand list.

A search mechanism was used to find the elements of the search strand list within each of the databases. An example of the results of that search are depicted in Table 2. The listing contained the database in which a match for the search element was found, the article in which it was found, the page number of the article, and an excerpt of each match. Summary statistics for each element were appended at the close for that element's entries. The complete listing can be found in Addendum C to this paper. There were 14,060 total element matches found in this search.

Item number	6.	>>>>	Looking for key word/phrase 'accuracy'	<<<<<
BMT	8.D.1	p. 198	n, and some means of checking for <u>accuracy</u> is needed	
VAT	II.C.4.3	p. 89	, efficient use of materials, and <u>accuracy</u> of construction; all items rated acceptable	
VAT	II.E.11.6.7	p. 203	explain the importance of <u>accuracy</u> and clarity in company communications	
VAT	II.C.13.3	p. 227	es and distribution records; 100% <u>accuracy</u> required	
VAT	II.C.13.4	p. 229	profit/loss statement; 100% <u>accuracy</u> required	
VAT	II.C.13.5	p. 231	liquidation reports; 100% <u>accuracy</u> required	
BMM total -	0.	BMS total -	0.	BMT total -
VAM total -	1.	VAS total -	0.	VAT total -
VBM total -	0.	VBS total -	0.	VBT total -
0. Total Occurrences - 6.				

Table 2 - Example of the results of a strand search for the element 'accuracy.'

A summary mechanism was used to calculate numerical occurrences of those elements found in the search strand list. Evaluation comments for each element were added by the researcher. An example of the results of that evaluation are depicted in Table 3. The complete listing can be found in Addendum D to this paper.

The total number of matches within each cell and the total number of words used are listed in Table 4.

The distribution of occurrences were accumulated in 10 intervals as indicated in

Table 5. As depicted in Figure 1, the distribution was skewed toward fewer responses

This is the 6th of 555 entries in the strand search file. It represents the word or phrase "accuracy," which occurs 6 times in the nine available standards databases and 4,483 included data files.							
Count							
BMM	0	BMS	0	BMT	1	National	1
VAM	0	VAS	0	VAT	5	State	5
VBM	0	VBS	0	VBT	0	Local	0
Mathematics	0	Science	0	Technology	6	Total	6
Percentages							
BMM	0.00	BMS	0.00	BMT	0.93	National	0.28
VAM	0.00	VAS	0.00	VAT	0.43	State	0.34
VBM	0.00	VBS	0.00	VBT	0.00	Local	0.00
Mathematics	0.00	Science	0.00	Technology	0.33	Total	0.13
Remarks: Contextual correlation was established for the 6 usages of the word accuracy found in two different technology standards levels. Checking for and requiring accuracy was considered synonymous.							

Table 3 - Example of the results of an evaluation for the element 'accuracy.'

	Mathematics	Science	Technology	Level totals
American Association for the Advancement of Science's Benchmarks for Science Literacy	79 arts 403 hits 158 words	165 arts 1125 hits 290 words	108 arts 657 hits 231 words	352 arts 2185 hits 340 words
Virginia's Standards of Learning	121 arts 576 hits 144 words	184 arts 652 hits 202 words	1163 arts 3595 hits 246 words	1468 arts 4823 hits 351 words
Virginia Beach City Public Schools' Learning Objectives	1740 arts 3634 hits 168 words	362 arts 1238 hits 239 words	561 arts 2180 hits 165 words	2663 arts 7052 hits 343 words
Discipline totals	1940 arts 4613 hits 243 words	711 arts 3015 hits 372 words	1832 arts 6432 hits 342 words	4483 arts 14060 hits 461 words

Table 4 - Summary of articles in reference cell, hits (occurrences of a match), and total words used in cell articles.

per word with a few elements accounting for a disproportionate number of responses.

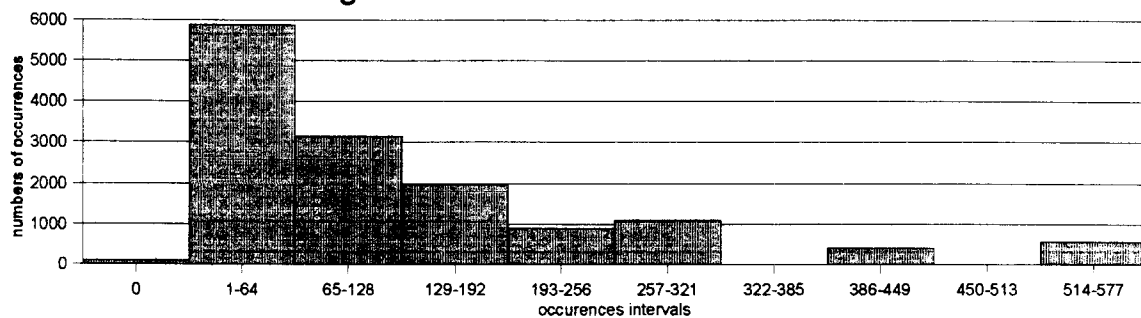
The mean of occurrences was 25.33 while the standard deviation was 51.1. The mode of the distributions was 1 while the median was 7 matches. They are more representative than are the classic measures of central tendency in this situation.

The categorization of correlation that resulted from evaluation can be found in Table 6. 96 elements of the search strand list, or 17.3%, resulted in "No entries found." 86 elements, or 15.5%, resulted in entries that could not be correlated as they either constituted single usages or usage was restricted to a single database. 82 elements, or

Intervals	Word Count	Occurrences	Average Occurrence per Word
0	94	0	0.00
1-64	403	5901	14.64
65-128	34	3143	92.44
129-192	12	1985	152.69
193-256	4	896	224.00
257-321	4	1108	277.00
322-385	0	0	0.00
386-449	1	404	404.00
450-513	0	0	0.00
514-577	1	577	577.00

Table 5 - Distribution of number of occurrences to the strand search elements.

Figure 1 - Distribution of Matches



Category	Sub-Category	Sub-Levels	# of entries	Definition	
Correlated	Complete		15	There is similar usage at all three levels and in all three disciplines	
	General		119	There is similar usage at all three levels and in at least one disciplines	
	Partial - 2 Levels	National - State		32	There is similar usages at two levels and in at least one discipline.
		National - Local		26	
		State - Local		96	
	Partial - at Level	National		22	There is similar usage in one level and in at least two disciplines.
		State		3	
Local			1		
Non-Correlated	General		82	There is no similarity in word usage.	
	Same Cell		38	All occurrences of the word or phrase occurred in the same cell.	
	Single Entry		48	The only occurrence of the word or phrase cannot be compared.	
No entries			96	There were no entries found.	

Table 6 - Summary of results of correlation categorization.

14.8%, were evaluated to be non-correlated by reason of contextual usage. 291 elements, or 52.4%, were evaluated as having one or more forms of contextual correlation between two or more cells.

COMPARISON OF GROUPS

Of particular interest to this study was a comparison of the national, state, and local level standards and their respective correlations or, viewed from another perspective, their uniqueness.

As indicated in Table 6, the national standards that attempted to integrate or coordinate curricula had 22 additional items held in common by all three disciplines at the national level, 32 additional items held uniquely in common with state standards, and 26 more items held uniquely in common with local standards for a total of 214 items that achieved some degree of correlation. This represented 73.5% correlation of those items for which correlation was established but only 38.6% of the search strand list elements .

Likewise, state standards that attempted to integrate or coordinate curricula had 3 additional items held in common by all three disciplines at the state level, 32 additional items held in common with national standards, and 96 items held in common with solely local standards for a total of 265 items with some form of correlation. This represented a 91.1% correlation of those items for which correlation was established but only 47.7% of the search strand list elements.

It was interesting to note that local standards had only 1 additional item held in common by all three disciplines at the local level, and, considering the items shared

uniquely in common with state or national standards, a total of 257 items showed some form of correlation. This represented 88.3% correlation of those items for which correlation was established but only 46.3% of the search strand list elements.

In the category of uniqueness, though the search strand list was drawn from all standards, some words appeared uniquely in one cell, level or discipline. Table 7 represents the 175 words found to have unique usage. Of the search strand elements found to be unique, the science discipline, with a total of 81 or 46.3% of the words uniquely used, seemed to be the most numerous. Words used only within a disciplinary field, i.e., mathematics, science, or technology, totaled 63 or 36 % of the unique words and were the second most numerous category. The third most numerous grouping of unique words were words that occurred at the national level, 52 total or 29.7%.

Used in BMM cell only - 3 2, 214, 529	Used in BMS cell only - 27 1, 76, 81, 125, 131, 132, 135, 136, 137, 151, 152, 203, 231, 232, 256, 260, 324, 327, 335, 347, 356, 362, 440, 445, 451, 534, 540	Used in BMT cell only - 9 10, 216, 263, 270, 319, 332, 387, 495, 527	Used at National Level only, two or more disciplines - 13 22, 150, 213, 239, 276, 294, 320, 361, 382, 396, 491, 517, 548
Used in VAM cell only - 2 296, 404	Used in VAS cell only - 7 5, 117, 149, 171, 262, 311, 353	Used in VAT cell only - 17 12, 34, 47, 54, 78, 79, 122, 212, 219, 329, 339, 416, 473, 504, 533, 542, 543	Used at State Level only, two or more disciplines - 5 57, 266, 432, 478, 522
Used in VBM cell only - 6 409, 410, 482, 485, 492, 497	Used in VBS cell only - 15 8, 102, 114, 133, 167, 176, 209, 247, 251, 269, 342, 365, 444, 537, 552	Used in VBT cell only - 7 38, 61, 189, 286, 419, 420, 498	Used at Local Level only, two or more disciplines - 1 224
Used in mathematics discipline only, two or more levels - 13 1, 15, 82, 110, 144, 200, 277, 279, 338, 363, 388, 453, 521	Used in science discipline only, two or more levels - 32 14, 41, 48, 50, 59, 62, 80, 180, 205, 220, 221, 227, 229, 268, 326, 328, 337, 349, 357, 373, 375, 400, 407, 471, 474, 483, 488, 489, 511, 512, 539, 546	Used in technology discipline only, two or more levels - 18 6, 11, 33, 83, 88, 109, 157, 177, 193, 297, 298, 354, 378, 399, 449, 470, 509, 526	

Table 7 - The distribution of unique usage. (# represent element reference number)

SUMMARY

This chapter discussed the source of the data analyzed, briefly discussed its

processing and intermediate products used in this project, presented distribution information concerning the frequency of usage of the 555 elements of the search strand list, and provided interval data for the distribution of matches finding the distribution to be non-normal. Correlation and uniqueness of elements and their usage in the respective standards databases was explored as well as contextual correlation ascribed to each national, state, and local level.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter will present the summary of this research project, determining the relationship between a local school division's middle school technology, science and mathematics course curricula and the accommodation of state and national goals, standards, or objectives attempting to achieve an integrated or coordinated curricula between those disciplines. Following the summary, the researcher offers conclusions to the stated problems and observations made during the conduct of the study. Finally, recommendations for future use of this information and for follow-on research efforts in the area of integrated or coordinated curricula development will be made.

SUMMARY

This research was conducted to determine if (1) an interdisciplinary, mathematics, science, and technology curricula was available, and if so, (2) was it evident in other necessary levels of goals, standards, and objectives and their associated documents. The perspective of local school division's was adopted determine if a concerned body of teachers had the information necessary to amend existing school division curricula guides to achieve integration or coordination in the revised materials and still support all state requirements. A national level guide, a set of state standards of learning and a local school division's curricula guides were used as a basis.

A review of literature clearly and continually indicated that interdisciplinary studies were part of any future reform efforts and that the new discipline of technology certainly

had merit in that context. The goal of integrated or coordinated curricula was to be sought. Literature also indicated that many discipline oriented organizations were in the process of amending existent standards or creating new ones, if none existed. There were only two efforts of note that were attempting to provide a basis for interdisciplinary education. From a standards perspective, the American Association for the Advancement of Science's *Benchmarks for Science Literacy* made an effort to provide science, mathematics and technology teaching goals from an integrated perspective. From a practical point of view, Virginia Tech's *Technology/Science/Mathematics Integration Project* attempted to provide a thematic overlay to existent curricula. Both approaches have merit but for different reasons. In the long term, the *Benchmarks* should result in consideration for revision of the formal standards documents used by all state departments of education and constitutes a first effort in formal reform. In the short term, the *T/S/M Integration Project* has provided tangible materials through which some level of coordinated study of technology, science and mathematics might be accomplished.

This study attempted to trace the commonality of the longer term approach, the standards from the *Benchmarks* to the local school division's curricula guides. The strand search approach was adopted to compare available standards. The data analyzed and information created for statistical analysis was nominal, at best, and relied heavily on evaluation of the context in which words or phrases were used to determine if they were intended to achieve the same educational objective.

CONCLUSIONS

The following conclusions were made based on the acquired information manipulated into databases for comparison and the resultant comparison and correlation.

Research question one. Are interdisciplinary, integrated or coordinated curricula available? Initial, conceptual efforts are available on the national level through projects such as the *Benchmarks for Science Literacy*. The document is, by nature, a guideline document and, is at this time, not binding on any other level of educators.

Research question two. What is the relationship between a local school division's middle school's technology, science and mathematics course curricula and its accommodation of state and national goals, standards and objectives? From the perspective of a local school division, there is a higher reliability of achieving state standards than national but compliance seems to be a relative quantity. There were few direct quotes of requirements at subordinate levels. In fact, using the methodology of this study, there was evidence of only 38.6% correlation of national level guidelines in state and local standards. There was evidence of only 47.7% correlation of state to national and local standards and evidence of only 46.3% correlation of local to national and state standards. While a simplistic assessment, there are indications that little attention is paid to upper level standards except as they apply through respective disciplines. The key issues or side issues of each strand search showed significant variation. 94 of the 555 commonly used and relevant terms (16.9%), though used in general discussion, were not found in any standards' usage. There were also indications of unique usage of common words or phrases, 175 of 555 terms (31.5%) which were used along lines of either a discipline, level of agency, or specific agency/discipline panel.

The observation of the researcher, during the period of acquiring the documents used as “standards,” was that acquiring relevant documents was not an easy task, especially if they were expected to be in a useable form. The sheer number and size of documents that serve as guidelines would overwhelm all but the staunchest curricula reform team members, especially if there was a desire to compare and refine intent or interpretation of available documents. The term “too hard for the average teacher,” if nothing more than from a time factor point of view, is appropriate. The ease of analysis and use of available standard is enhanced by use from a database format manipulated by information processing equipment.

The analysis of context in which key words and phrases are used revealed substantial differences in interest. General consensus was achieved in only 15 of the 555 terms used (2.7%). There were only 119 of 555 words used (21.4%) in a way identifiable and traceable through all three levels of standards. As this study was done with a document coordinated through an agency located near our nation’s capital, state standards from a state whose capital in less than a two hour commute, and curricula guides from a school division only four hours distant. It is conceivable that regional issues or issues driven by other factors caused by a different mix of population, different climate, different native tongues, or different situational usage of language could cause even greater non-correlation.

Disciplinary field usage of language continues to be a problem.

RECOMMENDATIONS

The following recommendations are made as a result of this study:

1. The lack of ease or expedience in comparing standards documents may be at the root of some of the disparity noted. Even for the above average teaching team who might be interested in teaching an integrated curricula in a middle school, its just too hard. Having recently watched a curriculum leader elected to a panel reviewing an aspect of national biology education, the short notice given, the breadth of standards with which the exemplarily qualified educator was expected to be conversant, and the short duration of the deliberations necessitated extraordinary efforts. An easy, comprehensive method for comparing standards from national, state, and local agencies, and objectives now found in most of the more recent generation of textbooks is at the core of a clearer path toward an interdisciplinary, integrated, or coordinated curricula. This is a necessary first step. A project to achieve such a vehicle is in order and should be funded to allow appropriate research and development by individual, knowledgeable educators who have adequate time to create a protocol.
2. A common list of concepts, ideas, processes, required knowledge, and goals common to all disciplines does not exist. The search strand list used by this study was an attempt to create such a “list of commonality.” More knowledgeable individuals should be called to create a common grounds list for use by all disciplines.
3. A more comprehensive algorithm for contextual comparison would be

helpful. This researcher will endeavor to improve upon the contextual approach using a primary word or phrase and a secondary line of reasoning. It is feasible to automate such a process given time and resources.

4. Technology, science and mathematics integration/coordination efforts should continue. However, the mechanisms that would aid an individual teacher in achieving the interdisciplinary perspective must be taught rather than assumed. Education preparation courses should be devised and taught that provide the maps and navigation aids needed to approach this aspect of reform.
5. Old Dominion University, assisted by grant agencies, should pursue the development of teacher preparation courses that discuss this subject.

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APPENDICES

APPENDIX A - Search Strand Word or Phrase List

APPENDIX A

Search Strand Word or Phrase List

absorb	behavior	commerce
abstract	biochemical	commercial
abstraction	biological	common
accelerate	biology	communicate
acceleration	biome	communist
accuracy	build	communistic
accurate	burn	compare
acid rain	calculate	compile
advanced	calculation	complex
agricultural	capacity	composition
agriculture	capital	comprehend
aircraft	capitalist	comprehension
airfoil	capitalistic	computation
alcohol	carry out	compute
algebraic	cells	computer
algorithm	cellular	concentrate
alternate	cellulose	concentration
alternative	ceramic	concept
amino acids	chain	conclude
amplifier	change	conclusion
amplify	changes	conclusions
analog	chaos	conduct
analyze	character	conflict
animal	characteristic	congruent
application	characteristics	consequence
applied	charge	consequences
apply	charges	conservation
approximate	chart	conserve
area	check	construct
argue	chemical	consume
argument	chemicals	continuous
assemble	circle	contribute
assembly	circular	control
assess	civil rights	conversion
atom	clarification	convert
atomic	clarify	cooperate
attraction	climate	coordinate
automated	climatic	coordinated
automatic	coefficient	coordination
average	cohesion	correlate
bacteria	color	correlation
basic	combine	correspond
basic number skills	combustion	correspondence

create	draw	flexibility
creative	drawing	flow
creativity	earth	fluid
critical	eclipse	foil
critical thinking	economic	force
cultivate	ecological	forces
cultural	ecology	formula
culture	ecosystem	fossil-fuel
curved	education	fossil fuel
cycle	elaborate	fraction
data	electrical	fractions
decide	electromagnetic	friction
decimal	electromotive	function
decision	electron	fungi
deductive	electronic	fungus
define	elements	galaxies
deforest	ellipse	galaxy
deforestation	energy	gas
demonstrate	engine	generate
density	engineer	genetic
depict	enterprise	geology
deplete	environment	geometrical
depletion	equilibrium	global
depth	equivalent	government
describe	equivalents	graph
description	establish	gravitational
design	estimate	gravity
desirable	estimation	group
detect	ethic	health
detection	ethical	hear
determine	ethics	heat
develop	event	heredity
diagnosis	evolution	historic
diagram	evolve	history
diameter	examine	human
differences	explain	hypothesis
digital	exploration	hypothesize
dilute	explore	identify
discrete	express	identity
discuss	fasten	illustrate
distance	feet per second	immune
diversity	figure out	inductive
drag	find	industrial

industry	mathematical	occurrence
infection	mathematics	opinion
information	matter	orbit
inorganic	mean	order
inspecting	measure	organic
instrument	measurement	organism
instrumentation	mechanical	organize
integrate	mental	outcomes
interact	metal	oxidation
interaction	meteor	packaging
interdependence	meteorite	parallel
international	meteorological	participate
interpret	meter	particles
investigate	meters per second	pattern
judge	method	patterns
judgement	metric	percent
keep a notebook	metrology	percentage
key-word	migration	permanent
key word	miles per hour	perpendicular
kilo	model	personal
kilometer	molecule	pesticides
kilometers per hour	monitor	phenomena
layer	monitoring	phenomenon
learn	moon	physical
learning	moons	physiology
length	moral	plagues
life	motion	plan
lift	motor	plane
light	muscle	planet
liquid	natural	planetary
liter	natural disasters	planets
locate	natural resources	plants
logarithmic	nature	plate
logic	nerves	political
logical	nervous	population
magnitude	neutron	power
manipulate	notation	precipitation
manipulation	notebook	precision
manual	numeric	present
manufacture	numerical	preservation
mass	nutrition	price
materials	observations	principles
mathematic	observe	private

probability	resources	speed
problem	retrieval	spin-off
problem-solving	retrieve	spin off
problem solving	rotate	star
process	rotation	storage
produce	safety	store
production	salient	structure
products	sample	substitute
proportional	satellite	substitution
proportions	satellites	sugar
proposal	scale	summarize
proposed	science	sums
proton	scientific	sun
psychological	scientific method	sunlight
psychology	scientific research	survival
qualitative	see	survive
quantitative	select	symbol
quantity	selection	symbolic
radiate	send	symmetrical
radiation	sense	symmetry
radio	senses	synthesize
radius	set	synthetic
random	sets	system
rate	shape	systematic
read	simple	systems model
reasoning	size	tabulate
receive	sketch	tactile
recognize	smell	take readings
recommend	social	take
rectangle	socialist	tangent
rectangular	socialistic	team
reduction	socialized	technological
refined	societal	technology
related	society	temperature
relationship	solar	temporary
relative	solid	testing
renewable	solve	theoretical
renewal	sound	theory
report	space	tides
repulsion	speak	time
research	species	touch
resource	specific	trace
resourceful	speech	trade

trade-offs
transfer
transform
transformation
translate
transmission
transmutation
transmute
transport
transportation
treatment
trend
trends
uncertain
uncertainty
understand
undesirable
universe
use
values
velocity
verbal
vibration
vibrations
virus
vision
vocabulary
volume
wave
wavelength
waves
weather
weigh
weight
welfare
width
wind
wood
write