5-1993

Effects of Science Vocabulary Exposure Prior to Instruction: Interdisciplinary Instruction in Science and Language

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EFFECTS OF SCIENCE VOCABULARY EXPOSURE PRIOR TO INSTRUCTION: INTERDISCIPLINARY INSTRUCTION IN SCIENCE AND LANGUAGE

Submitted to the Graduate Committee of the
Department of Education and Human Development
State University of New York
College at Brockport
in Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Education

by

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May 1993

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Abstract

This study investigated the use of a prereading strategy that gave 6th grade students exposure to technical science vocabulary before science instruction. The prior exposure consisted of listening/speaking and graphophonemic manipulation of the science terms. The science instruction promoted student inquiry and problem solving in each of the three phases of the science unit on rocketry. These phases were model construction, informational material and "hands-on" experiments.

A treatment-control group comparison was conducted. After each of the phases a posttest was given to both groups. Data were collected and compared for three posttests. The technical vocabulary awareness treatment group demonstrated no significant advantage in their science concept learning as a result of having receiving the prior vocabulary exposure. It was noteworthy that a majority of the students in both groups received average to superior + posttest scores indicating a good mastery of the science concepts.

Dedication

To God be the Glory

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Chapter I

Statement of the Problem

> "Through our science and technology we are capable of comprehending the breathtaking majesty of the universe we live in and literally reach out to the stars"
>
> John Glenn,
> Astronaut

Science education today is exciting, encompassing vast fields of study for all students from kindergarten to the universities. This excitement directly stems from the Russian's launching in 1957 of the Sputnik 2. This meant uncomfortably, that the Russians had streaked ahead in rocket technology. U.S. political and military sections of the government were in a state of turmoil. The reverberation of this event sifted down into the educational systems and shook them into revising and revamping science instruction. The American Association for the Advancement of Science began to enumerate goals for all students in public education as did federal and state education systems.

One dramatic change was the study of the teaching-learning correlation. The conclusion reached was that children must experience science beyond the textbook. That was not to say that texts and relevant written materials should be disregarded.

Rather, they are only a part of the whole in science literacy. Mitman, Mergendoeller, Marchman & Packer (1987) define science literacy as:

> the meaning and utility of science will develop not as a function of the accumulations and retentions of facts but as a function of understanding the importance and meaningfulness in connection with the other broader contexts of human endeavor (p. 612).

"Broader contexts" interprets into meaning that student involvement and science learning become a part of the student experience (Boaz, 1965, p.3). No principle of science should ever be taught unless the students have opportunity to make it their own through experimentation, inquiry, observing, measuring, inferring, interpreting and communicating. A key word was coined for this science learning as "hands-on."

Because science implicates the whole child, communication or language is paramount. Language involved in listening, speaking, reading and writing communicates the science experience. It is a dominant part of science literacy. Science teachers as well as other content area teachers do not always address the need to incorporate into their instruction and plans the language teaching needed for students to learn concepts deeply and personally. The language of science or technical vocabulary can be overwhelming and unattainable to students who have never encountered it before. Their lack of science vocabulary awareness can impede concept and context comprehension.

Science instruction has come a very long way in making science exciting for students. One added dimension that needs to be explored is that technical vocabulary instruction be included to make the terminology not only meaningful but part of the student's vocabulary.

Purpose

Students need preparatory strategies to help them when they encounter unfamiliar vocabulary and concepts in science. The purpose of this study was to examine a method of promoting technical science vocabulary awareness prior to constructing a science model, prior to reading informational material and prior to participating in "hands-on" experiments.

Question To Be Asked

Are science concept learnings among sixth grade students facilitated if students complete listening/speaking activities and graphophonemic manipulation of technical science vocabulary in advance of model construction, informational reading and/or experiments?

Need For the Study

Sputnik shocked science educators into curriculum reconstruction and reorganization. Current science programs evolved to incorporate the following goals: problem solving, science skills, science content and science attitudes as stated in the New York

Elementary Science Syllabus (1990). The purpose for these goals is for students to increase their science literacy. Literacy means language and science literacy means science dependent on language. Whole Language classrooms are becoming whole learning environments with all content area subjects involved. Teachers in middle schools and high schools that are departmentalized need to realize the language connections in all disciplines. They should develop methods of teaching that include reading and writing.

Many science teachers do not understand their responsiblity in effectively teaching science content and skills through reading strategies. They are trained and equipped in their content area only. Few have had reading methods classes in their undergraduate work. Most feel that students should come to their classes able to read. Reading is developmental according to Goodman, Smith, Meredith & Goodman (1987) and should extend past the elementary grades into high school and beyond. All teachers should provide instruction that enables students to cope with the wide variety and complexities of materials assigned to them. (Gee, 1989).

Directions for model construction, science text materials, and experiments that are to be read contain technical science language. This technical language rests on vocabulary awareness prior to encountering it in written materials. Being able to pronounce the terms facilitates oral communication. Students often skip unfamiliar vocabulary and the vocabulary concept dependency breaks down (Stahl, 1986). Furthermore, some vocabulary is familiar to students but not in the related science context. For example "action" in a photography/movie class would mean something different than the action-reaction in Isaac Newton's Law of Forces. Asking students to look up meanings in a dictionary is not appropriate because the definitions often will be incorrect in the scientific sense (Miller & Gildea, 1987; Thelan, 1976). The concepts must be taught within the problem solving, skills, context and attitudes of the science goals. Science vocabulary awareness is preparing students to increase their science literacy. It is the beginning of the students ownership of their learnings.

How to effectively present this vocabulary or give students opportunities to speak and use it prior to their involvement in science tasks is the question.

Definitions

Whole Learning Learning that exhibits the whole language philosophy in all content areas (social studies, science, health, math, as well as English) (Anderson, 1984).

Functional Reading Reading to learn. Often it involves technical language above the independent reading level. (Thelan, 1976).

Developmental Reading Learning to read. A process that continues to evolve throughout life. It is based on print awareness and the language connection. It results from skill development determined by practice. (Goodman, et al. 1987).

Technical Vocabulary Specific terms used to describe or discuss science concepts (Johnson, 1984).

Science Literacy Acquiring knowledge, developing skills (inquiry, problem solving and content) and positive attitudes about the natural world (New York Elementary Science Syllabus, 1990).

Cloze Procedure An assessment procedure where key terms are excluded from concept statements in order to test student knowledge.

Hands-On The opportunities for students to learn science concepts by actually building models or structures, doing experimenting, while physically observing, measuring, inferring, interpreting, and communicating.

Summary

The Russian launching of a space vehicle sparked the educators in the United States to change their science programs to encompass the current relevant technological needs. One of the primary revisions was not only to raise students' interest level of the science content but also to actively involve the students. This implied studying the teaching-learning correlation. The literacy required in a optimum functional science program is based on language. Bonded with science concept learning is science language learning. Science teachers are not trained in language teaching. Since the language connection is so powerful in concept comprehension, this dimension needs to be added to science instruction.

Chapter II

Review of the Literature

Science and language educational programs have reformed in recent years because of the research which has investigated the teaching-learning correlation (Anderson, 1984; Goodman, 1986; Yager, 1990). Science literacy is the goal of the movement expectations with a special focus on student inquiry. Problem solving skills, positive science attitudes and knowledge acquisition are the recent science/technology/society programs (New York Science Syllabus, 1990; Yager 1991). This science literacy movement has communication at its core. Within the language instruction realm, whole language classrooms are becoming whole learning environments with content area subjects (Anderson, 1984). Many science teachers have not understood their responsibility to these reform movements. They believe their instruction encompasses the science curriculum only. Many teachers ignore or are unaware of science in practice. (Conley, Stewart & O'Brien 1989 in Hollingsworth & Teel, 1991).

Students acquire much of their science knowledge through reading texts, reference materials and science journals. Reading strategies before instruction are crucial to the teaching-learning correlation in science literacy (Abruscato, 1992, Goodman & Burke, 1980; Vacca & Vacca, 1986).

Lack of technical vocabulary knowledge can be a stumbling block in comprehension (Holloway & Teel, 1989; Klein, 1988; Thelan, 1976). Much of the science skills and concepts are based on technical vocabulary.

Science and Language Connection

Much of science learning can be paralleled to language learning. In inquiring about the environment, a child unconsciously hypothesizes, tests, evaluates, organizes and concludes (Piaget & Inhelder, 1969 in Goodman et al., 1987). New Learning happens. In decision making he sifts through what is valuable and what is not. The learning deepens.

> A newborn infant babbles, gurgles, wriggles and reaches out to touch the world. Each day you and I reach out to our surroundings in wonder. We are humans and we are wonderers. (Abruscato, 1992, p.6)

Inquiry is what a child is about, be it inquiry to learn his new language to communicate or acquire science concepts that explain his world.

Language learning begins with a child's listening; it develops from prior auditory exposure to words (Britton, 1970; Goodman et al., 1987). The language becomes purposeful as the child realizes its function is communication (Anderson, 1984). Likewise in science language learning, a child's science schema may begin with prior listening to technical terms and then progresses to comprehending and communicating.

In investigating the world, a child finds a need to name, to describe and to classify his experience. "Language becomes the medium of thought and learning - it is not until an idea is presented that the learning is complete" (Goodman et al., 1987, p.16). According to the New York Science Syllabus (1990), science language skills involve "classifying, developing specialized vocabulary, paraphrasing and summarizing, questioning, recording data and using key words and symbols" (p.16). The language processes needed are "acquiring information and developing concepts through active reading and listening and communicating informational concepts and attitudes through speaking and writing" (p.17).

Technical Science Vocabulary

Students often become frustrated and discouraged in their science learning because of the unfamiliar science language. At the middle and high school levels much of the content acquisition comes from reading informational materials. Wright (1982) discovered that reading was a vital tool for a successful science student. The reading abilities of the tenth grade students Wright studied ranged from fourth to twelfth grade. The textbooks he evaluated were usually at grade level readibility or one grade below. Thelan (1976) identifies the type of reading needed for those texts as functional or reading to learn. This reading involves technical language above the students' independent reading level and is identified as the instructional reading level. Special efforts to teach vocabulary are often needed so students can readily learn and communicate the concepts represented.

Stieglitz & Stieglitz (1981) emphasizes "the subject matter teacher must recognize the importance of words, whether printed, or spoken to the content area learning" (p.46). The connection between vocabulary learning and concept learning is powerful. Beck, Perfetti & McKeown (1987) conclude that "comprehension is grasped easily when a student is not detained by too many unfamiliar words or word meanings" (p.507). Johnson (1984) agrees that concepts are unattainable unless the vocabulary representing them is accessible. Moreover, any concept communication depends on the ability to associate written symbols and oral sounds with the ideas and/or objects they represent (Langer 1967). "If we are not alerted to the need to teach and reinforce reading skill development" [students experience] "continuing frustration with new vocabulary words" (Abruscato, 1992, p.95).

Smith (1965) recognizes that specialized vocabulary is a significant factor in science material and necessitates "providing vocabulary work before the student reads" (p.383). Every word in experiment procedures must be recognized in order to successfully carry out experiments. Explanations of technical processes, like following diagrams, rely on accurate vocabulary knowledge. Textbooks contained complicated explanations stating definitions or science principles. Vocabulary knowledge must exist to facilitate learning (Stevens, 1982).

Many researchers have examined varied methods of teaching vocabulary (Ehri & Wilce, 1980; Carmine, Kameenui & Coyle, 1984; Goodman 1986; Jenkins, Matlock & Slocum, 1989). However, those methods did not deal directly with vocabulary awareness. Exposure to unfamiliar words before the word is needed in context best describes awareness. Ives, Bursuk & Ives (1979) state:

> Before a name or meaning can be associated with a particular written form, that word must in some way be distinguished from all other word forms. (p.18)

They suggest visual configuration or a whole word structure and graphophonemic correspondence for initial word encounters. Gipe (1987) refers to visual stimuli as "perceptual or unit analysis" (p.109). Reading begins by perceiving such visual stimuli. Kaplan & Tuchman (1980) and Wood (1990) advocate frequent vocabulary pronunciations by instructors and students to insure auditory acquistion. McKeown, Beck, Omanson & Pope (1985) found in their research that "providing a moderate high number of encounters per word will yield significant outcomes" [learning] (p.534).

As students are exposed to the technical vocabulary, they begin to anticipate the concept learning associated with the terms. Gipe (1987) calls this a psychological set. Vacca (1977) states that such an anticipation puts students in a "state of mind that promotes learning" (p.387). Hunter's (1969) research recognizes that students who are engaged in overt and covert participation preceding learning are "affected in increasing speed and amount of learning" (p.78).

Science Program Reform Expectation

Effective science programs advocate a shift in emphasis from passive to active student involvement. Yager (1991) puts this into a clear perspective when he states:

> Today's science education research focuses more on students than teachers. With the emphasis on the learner, we see that learning is an active process occurring within and influenced by the learner as much as by the instructor and the school. From this perspective, learning outcomes do not depend on what the teacher presents. Rather, they are an interactive result of what information is encountered and how the student processes it based on perceived notions and existing personal knowledge. All learning is dependent upon language and communication. (p.53)

Student cooperative learning evolves in the exchange of science literacy accomplishments. The students' investigations bring the unknown to the known through a process of science skills, attitudes, problem solving, and science content.

Real science learning cannot be a result of teachers "presenting" information or "announcing" a new science module (Yager, 1990). Authentic learning is not a series of vicarious experiences via observation. Dantonio & Beisenherz (1990) concluded that just being a teacher with a strong science background was not necessarily the inspiration or motivation that makes students eager to learn nor does strong background promote positive student attitudes.

Rubino (1991), a science educator specialist, described her classroom environment as focused on problem solving, direct experimentation and observation. In addition she required journal writing, log recording, and process writing of expository reports. She discovered students' comprehension of principles improved when she combined these elements. Information became more concrete in this experiential setting. Students were enthusiastic about their learning and communicated it to others. They were creative and curious about future investigations.

Reading Instruction In Science

Unfortunately science teachers are rarely trained in developmental reading strategies. Middle and high school teachers expect students to be able to read and comprehend content material (Gillespie & Rasinski, 1989). In a survey of high school teachers, forty-five percent responded negatively to the statement "every high school teacher should teach reading." (Thelan 1976). The reading process is developmental and on going into adulthood (Goodman et al., 1987). Teachers have erroneously assumed that reading instruction should begin and end in elementary school.

Gee (1988) described some content area teachers as cognizant that reading-to-learn strategies were important. Some teachers believed that reading programs would overwhelmingly improve content learning. "Any inservices conducted by school administrators in reading strategies for content area teachers proved that student achievement was enhanced" (p.42).

Most middle and high school teachers are not trained to teach reading. Currently, universities require newly graduating teachers to take a single course in the teaching of reading (Texley, 1990). Most tenured teachers have not had an opportunity to take such a course (Gillespie & Rasinski, 1989). Conley, Stewart & O'Brien 1989 in Hollingsworth & Teel (1991) studied two science teachers who took a year long reading course for a graduate degree. After graduating, both teachers admitted they incorporated little of their course work into their classroom instruction.

A recent instructional philosophy is a Whole Language environment. Science teachers as well as other content area are encouraged to integrate trade books, informational materials and journal writing into their classes (Anderson, 1984; Goodman, 1986). Texley (1990) feels that most current research in the teaching of reading is applicable to the teaching of science.

> The trend promises to offer science students more facinating texts and more useful skills and may give birth to a love for science literature that will carry them into their adult years. (p.6).

Summary

A child best learns language and science concepts by inquiry. Language learning and science language learning begin with listening. Students' science literacy is dependent on communication skills. Unfamiliar technical science vocabulary can be a hinderance to comprehension. Vocabulary awareness is exposure to unfamiliar words before the need arises to use the word or understand its meaning. It is also a psychological set that prepares students to comprehend concepts. Science program reforms have transferred the focus from teacher instruction to student problem solving and decision making. This reform has overlooked the need for pre-reading strategies that facilitate student content learning.

Chapter III

Design of the Study

This study was designed to investigate the effect of a pre-reading strategy in a science program that uses varied procedures to teach science concepts. The specific reading strategy gave students prior exposure to technical vocabulary through listening, speaking and graphophonemic manipulation. The vocabulary was vital in observing, informing, measuring, interpreting, applying and communicating science concepts. The science program involved three phases: model construction, informational reading and laboratory experiments.

Hypotheses

The null hypotheses were as follows:

1. There will be no statistically significant difference in the posttest scores between sixth grade science students receiving pre-reading vocabulary practice relative to model construction and a control group not receiving this practice.
2. There will be no statistically significant difference in the posttest scores between sixth grade science students receiving pre-reading vocabulary practice relative to information material reading and a control group not receiving this practice.

3. There will be no statistically significant difference in the posttest scores between sixth grade science students receiving pre-reading vocabulary practice relative to laboratory experiments and a control group not receiving this practice.

Methodology

Subjects

The thirty subjects in this study were sixth graders in a small city school district in Western New York. This was a treatment-control design. Fifteen students from a science class of twenty-five were selected as the technical vocabulary awareness treatment group (TVAT). The whole class received the treatment, but these students' scores were evaluated for this study based on the fact that these students did not receive any supportive content curriculum in remedial reading or resource services. Another fifteen students from a separate science class of twenty-seven were chosen as the control group. Even though the whole class received the science instruction, these students were chosen because they had not received any academic support services. Both groups were homogenously grouped based on their reading composite national percentile scores of the California Test of Basic Skills (CTBS). Of the two classes, six students were eliminated from the study due to either poor attendance, lack of test score data necessary, or because the student had moved out of the school district.

Materials

The science materials and guidelines were used in conjunction with a Rocketry Unit from the Elementary Science Program (ESP) Monroe - 2 - Orleans Board of Cooperative Educational Services (BOCES). Consistent with the New York State Science Syllabus (1990), the ESP science kits require student inquiry and problem solving skills. The methods suggested in these kits incorporate "hands-on" formatted tasks to insure the optimum student participation and learning. Three phases of this unit were utilized in this study: model rocket construction, informational material and laboratory experiments (materials: Appendix A).

TVAT materials were prepared by the Crossword Magic computer program. The technical vocabulary terms selected were to be used in the crossword puzzle configuration. No context clues were given; the terms were simply repeated for this section rather than an explanation of concepts. One crossword puzzle was prepared for the model rocket construction, two for the informational material, and one for laboratory experiments (see Appendix A). Four answer keys produced by the Crossword Magic were copied onto overhead transparencies.

Model Rocket Construction: Eleven technical vocabulary words were chosen from the direction sheet for the Alpha Model Rocket for Beginners Kit. These terms were used for the crossword fill-in practice sheet designed for the TVAT group. A corresponding answer key transparency was also used. Each student was supplied with a model rocket kit and other necessary items to assemble the rocket. A researcher made cloze test was administered to evaluate vocabulary comprehension.

Informational Reading: Twenty-six technical vocabulary terms using the "Rocket" reference were selected from the World Book Encyclopedia. Two crossword fill-in practice sheets were made and the answer key copied onto the transparency for the TVAT group. The informational material was reproduced so that each student could have a packet. The second cloze test was administered to evaluate the vocabulary understanding acquired in this phase.

Experiments: Sixteen vocabulary words were chosen from eleven laboratory experiments. These were used to make the TVAT group's crossword fill-in practice sheet and answer key transparency. Each student was supplied with a scientific method data recording form and a packet of experiment procedures. Materials for eleven experiments were placed around the classroom for student access. The third cloze test was administered and scored to evaluate vocabulary comprehension. (See Appendix B for all cloze tests).

Instruments

The fourth and fifth grade average composite reading scores from the California Test of Basic Skills (CTBS) national percentile were compared for the TVAT group and the control gorup. This was done to establish that the reading ability for both groups was homogenous.

Three cloze formatted tests which were constructed corresponded to the three rocketry unit phases of instruction. The first test contained twelve technical vocabulary terms and concepts taught in the model rocket construction phase. A second cloze test contained twenty-nine technical vocabulary terms and concepts taught from the informational material packet. Finally, the third cloze test was constructed from the nineteen terms and concepts taught from the experiment procedures.

Procedures

In preparation for this study it was necessary to assess students' prior knowledge of rockets. Each student was asked to write a list of any familiar rocket terms. The lists were compiled and if a frequently tabulated term (appeared more than twice) was seen, that term was eliminated. One student recorded four terms that had been considered for this study. Upon being questioned as to scientific concept knowledge associated with these terms, the student failed to exhibit the appropriate understanding. The terms were thus included in the study.

The prior technical vocabulary awareness treatment procedures were similar for all three phases of instruction. In the first phase of model construction, each student in the TVAT group's science class was given a crossword fill-in with the terms in the clue section. Students were told that understanding the terms was necessary to construct the model rocket. Students were to overview their puzzles silently, then listen carefully as the terms were pronounced. It was suggested that students use pencils to record the terms' graphics onto the crossword matrix. Incorrect answers could then be easily erased. Students were encouraged to discuss and compare their answers with friends. Upon completing the workpaper, students were asked to read the terms to each other. An overhead transparency answer key displayed the answers and the students made their correlations. Again the terms were pronounced. The practice papers were collected and inspected to determine if all students had completed the task. This treatment took ten minutes.

The control group was previously told to bring science related books to class. All space travel material was excluded.

This group spent the beginning of the period in sustained silent reading (SSR). The time spent in this activity was comparable to the TVAT group's treatment time.

Both groups participated in the following instruction. Even though they were in separate class time periods, the same concepts were taught and the same materials used. Students read the directions from the Alpha Model Rocket for Beginners Kit and proceeded to assemble the rockets. Procedures for the construction were discussed and reviewed. Cooperative learning was permitted. A cloze test was administered the day following the completion of the model rocket. Students were encouraged to study the model rocket directions in preparation for this test and the TVAT group's class was given its crossword puzzle fill-in as a review. The tests were corrected by the researcher.

For the informational material phase, the TVAT procedures were exactly the same as the first treatment. Two crossword fill-ins were constructed because of the number of terms. The directions from the previous treatment were duplicated and students proceeded to listen, speak and complete their crossword sheets. The control group was assigned an SSR time comparable to the treatment group's time.

Packets of the "Rocket" reference were distributed to students in both science classes. Some pre-reading discussion about rockets occurred. Students were asked to read the material silently. A second reading was permitted in small groups.

One variation occurred for the TVAT group's class. At this second reading, students were asked to highlight all crossword fill-in terms found in the "Rocket" reference packets. When this was completed, the crossword fill-in and the "Rocket" packets were collected. These packets were surveyed to insure that the task had been completed. The packets were returned for a future assignment.

Research writing procedures were discussed in both science classes. Students were instructed to outline the reports. Students worked through the writing process: research, prewrite, rough draft, revision, edit, and final copy. Time was permitted in the science class for this process. The final reports were graded by the language teacher. A cloze test was administered the day after completion of this assignment. Study and review for this test was encouraged. The TVAT group's class used their crossword fill-in for the review. Also, rocket packets were returned to all students in both classes.

Prior to the third phase, experiment instruction, the TVAT group's class received a crossword fill-in of nineteen terms. The directions for this treatment were repeated as in the past two treatments. The control group used the same amount of time in SSR as did the TVAT for the treatment. The instruction for the experiments involved eleven centers supplied with materials for performing each experiment. Students were instructed in the scientific method: question, hypotheses, procedure, observation, and conclusion. Each experiment procedure was conducted in small cooperative groups. Data were recorded. Much discussion and use of technical terms were needed. When all students had the data sheet completed, the conclusion portion of the experiments was discussed. Students were told to study for a test the following day. The TVAT group's class had their crossword fill-in returned for review purposes. The researcher scored all tests.

Analysis of Data

A *t* test and an unweighted means solution of two-way factorial design was used to determine the reading ability levels of the TVAT group compared to the control group. This was to eliminate a variable of advantage. Likewise, an independent *t* test was used to test the hypotheses at the .05 confidence level. The mean and standard deviation of the TVAT group was compared to the mean and standard deviation of the control group in the model rocket construction cloze posttest. The mean and standard deviation of the TVAT group was compared to the mean and standard deviation of the control group from the informational materials cloze posttest. Finally, the mean and standard deviation of each group was compared from the experiments cloze posttest.

A post hoc Pearson product-moment correlation coefficient of the two groups was computed at alpha .05. A second post hoc percent table was calculated by the percent of students out of 30 who attained average to superior + scores.

Summary

This study was designed to investigate the effect of a pre-reading strategy in a science program that uses varied procedures in teaching concepts. Thirty students from a small city school district were involved in this study. Fifteen students in one class period were considered the technical vocabulary awareness treatment group (TVAT); fifteen students in another class period were the control group. The science program on rocketry contained three phases: model rocket construction, informational material and experiments. The TVAT group received three pre-reading treatments prior to the instruction given for these three phases. The control group did not. A cloze test was given following the instruction for each phase. The group's three scores were compared and analyzed in order to discover if the pre-reading treatment improved students' science knowledge.

Chapter IV

Statistical Analysis

Students need preparatory strategies to assist them in concept comprehension when they encounter unfamiliar vocabulary and concepts in science. The purpose of this study was to examine a method of promoting technical science vocabulary awareness prior to constructing a science model, prior to reading informational material and prior to doing "hands-on" experiments.

It was necessary to establish that the reading ability levels for the two groups examined were not significantly different. This was to eliminate a variable of advantage. Thus, the averages of the fourth and fifth grade national percentile reading composite scores from the California Test of Basic Skills were analyzed using the independent t. Both groups' reading abilities were found to be homogenous.

Findings and Interpretations

The following null hypotheses were examined:

1. There will be no statistically significant difference in the posttest scores between the 6th grade science students receiving pre-reading vocabulary practice relative to model construction and a control group not receiving this practice.

2. There is no statistically significant difference in the posttest scores between 6th grade science students receiving pre-reading vocabulary practice relative to informational material reading and a control group not receiving this practice.

3. There will be no statistically significant difference in the posttest scores between the 6th grade science students receiving pre-reading vocabulary practice relative to laboratory experiments and a control group not receiving this practice.

Table 1

Model Rocket Construction
(Null Hypothesis #1)

Group	Posttest
TVAT	
mean	93.47
standard deviation	13.36
Control	
mean	92.67
standard deviation	8.96
crit. *t* (.05)=2.048	0.19

As the data in Table 1 illustrates, the TVAT groups'mean score was higher than the control group but there was no statistically significant difference between the two groups. Since the critical value of the *t* required at 28 degrees of freedom at the 95% confidence level is ±2.048 and the obtained *t* is 0.19, null hypothesis #1 is retained.

Table 2

Informational Material
(Null Hypothesis #2)

Group	Posttest
TVAT	
mean	81.67
standard deviation	21.05
Control	
mean	83.73
standard deviation	12.99
crit. *t* (.05)=2.048	.32

As the data in Table 2 illustrates, the control group's score is higher, but there is no statistically significant difference between the two groups. Since the critical value of the *t* required at 28 degrees of freedom at the 95% confidence level is +2.048 and the obtained *t* is 32, null hypothesis #2 is retained.

Table 3

Experiments
(Null Hypothesis #3)

Group	Posttest
TVAT	
mean	90.80
standard deviation	15.29
Control	
mean	91.2
standard deviation	9.50
crit. t (.05)= 2.048	0.09

The control group's mean is higher but there is no statistically significant difference between the two groups (Table 3). At 28 degrees of freedom at the 95% confidence level the critical value of t is +2.048. The obtained t is 0.09. Null hypothesis # 3 is retained.

Post Hoc Analysis

Even though this study's purpose was not to examine instruction effectiveness and posttest correlations, some interesting observations were made.

Table 4

Vocabulary Cmprehension Learning

TVAT and Control Group's Combined Cloze Posttest Scores

n = 30

Posttest Scores Based on % correct	Tests			Status
	Model Construction	Informational Material	Experiments	
100-108	36.7%	13.3%	36.7%	superior +
90-99	23.3%	23.3%	16.7%	above aver - super
80-89	30%	36.7%	33.3%	aver to above aver
70-79	10%	6%	6%	below average
little success	0%	20%	6%	failure

Combining the percentages for both groups for model construction discloses that 90% of the students accomplished average to superior vocabulary comprehension. The informational material combined scores reveal 73.3% of the students understood the vocabulary at a status of average to superior +. 86.7% of the students attained the same vocabulary comprehension status for the experiments. The "hands-on" tasks, it is concluded, have higher percentages of vocabulary learning than the reading informational material (See Appendix D for raw score for both groups).

Table 5

Pearson Product Moment Correlation Coefficient

	Model Rocket	Informational Material	Experiments
5th Grade CTBS	.53	.62	.71
Model Construction	-	.75	.54
Informational Material	-	-	.65

alpha .05 critical value = .3809

The Pearson Product moment correlation coefficient at 28 degrees of freedom at a 95% confidence level is 0.3495. All correlation coefficients are above this level and are expressed as moderate to good positive correlations.

As reading composite national percentile scores increased, so did the scores on all three science cloze posttests; the higher correlation being with experiments. In observation of the three phase posttests, the highest positive correlation was between the scores for informational materials and model construction. As the scores for model construction increased, so did informational material scores increased. These increases indicate that students who read well will also do better in the "hands-on" activities.

Summary

The purpose of this study was to examine a method of promoting technical science vocabulary awareness. The TVAT group's scores did not display any significant gain in vocabulary comprehension in the model construction posttest, nor in the informational material posttest, nor in the experiments posttest. The post hoc data revealed that a high percentage of science vocabulary comprehension occurred in both groups. The Pearson product moment correlation coefficient attested to a positive moderate - good correlation strength between the CTBS reading ability scores and each of the three science phase tasks. As the three phase tasks posttest scores were examined, there were positive moderate - good correlations indicated among them.

Chapter V

Purpose

Students need preparatory strategies to help them when they encounter unfamiliar vocabulary and concepts in science. The purpose of this study was to examine a method of promoting technical science vocabulary awareness prior to constructing a science model, prior to reading informational material and prior to participating in "hands-on" experiments.

Conclusion

This research demonstrated that there is no significant difference in concept comprehension gains for students who participated in the prior science technical vocabulary awareness treatment (TVAT) compared to students who did not have such instruction. The treatment alone appeared to be too minute a dissection of any pre-reading strategy to produce a learning advantage. Perhaps the exposure needed to be expanded to involve intermittent "reminders" of the technical science vocabulary pronunciations and configurations. Such practice activities could reinforce concepts.

Miller & Gildea (1987) stated, "mastering the mechanics of uttering and recognizing a word and mastering the concepts it expresses are separate learning processes" (p.44). Support for this statement existed in this reasearch. All students in the TVAT group mastered the configuration and pronunciation of all the terms. However some students were challenged by the complexity of the concept meanings the terms represented. Some students had difficulty processing directions for the model rocket construction and the experiment tasks. The abundance of factual concentration in the informational material overwhelmed some students. (See Appendix B on the subject of "propellants").

It is worthy to note that the majority of the students in the TVAT group and the control group attained an average-superior + status on their cloze posttests. This indicates that a high level of the science principles were mastered. The success of student learning as suggested by Yager (1991) could be attributed to the fact that the focus of this science research was on student inquiry and problem solving. Students commented about how pleased they were to have learned so much about rocketry.

Wright (1989) stated that the stronger the reader, the better the science student. This statement demonstrated in the research (see correlation Table 4). The highest positive correlation was between reading/researching informational material and the model rocket construction task. Furthermore, those students who did well on their CTBS composite reading scores did well on posttests for the three science phases. Helping students become better readers of science materials should ultimately improve their ability to accomplish science tasks.

Implications for Research

Research Improvement

The following recommendations are suggested to improve studies similar to this research. An increase in the sample size and an increase in the duration of the research may affect the results. Using other grade levels may give guidance as to what types of vocabulary exposure are effective. Vocabulary exposure may help students who have learning difficulties.

Within the science instruction, the same lesson was given twice. This researcher felt the second lesson taught to the control group exhibited improved instruction. A video tape of the lessons might insure equal instruction quality.

In selecting groups, the "class personality" or "make-up" should be considered. Even though the reading abilities of the TVAT group and the control group were similar, the researcher observed some qualities in the students' behavior that may have affected the results of this study. The TVAT group appeared immature and unable to concentrate on tasks.

Some members of the class demonstrated negative attitudes towards science and learning. This influenced the class as a whole; time had to be spent dealing with these immature behaviors. In selecting groups, a student questionnaire could be given to ascertain attitudes which may interfere with learning.

Future Research

It would be valuable to investigate an expanded vocabulary exposure in science content. The prior exposure should include variations of word searches and puzzles. A continuation of the exposure during instruction could consist of word practices on flashcards or other intermittent "reminders." At the end of each science phase, students could review the terms and the concepts the terms represent as preparation for the posttests.

Future research could also involve quantitative investigations of the following questions.

1. Are science teachers teaching reading strategies and if so, how do they do this?

2. Are science teachers aware of the current trends in reading and if so, how do these trends influence their science instruction?

3. Do science teachers focus on student problem solving?

4. Are English/language teachers aware of the science curriculum and how they might support that curriculum with their own?

5. Are English/language teachers engaging students in writing expository science essays and are students taught how to use research skills as part of the writing process?

Implications for Classroom Practice

The main goal of content areas teachers is to teach the process of learning not to impart content information (Orasanu, 1986). Science instruction should combine with language instruction, problem solving strategies, positive attitudes, skills, and content. Since better readers usually become better science students (Wright, 1982), instructional time needs to be spent teaching science students reading strategies. For example, the introduction of technical terms permits students to correctly communicate their science learning. If science teachers are not trained in reading instruction, then school administrators need to provide inservice reading programs.

An unexpected outcome of this research has evolved; this research can serve as a model for some of the current trends in science and language education. Science instruction should be conducted with student centered activities such as constructing a science model, reading information materials and processing experiments. As demonstrated in the cloze posttest scores, a higher degree of learning resulted from "hands-on" tasks (see Table D). The science instruction incorporated whole language tasks.

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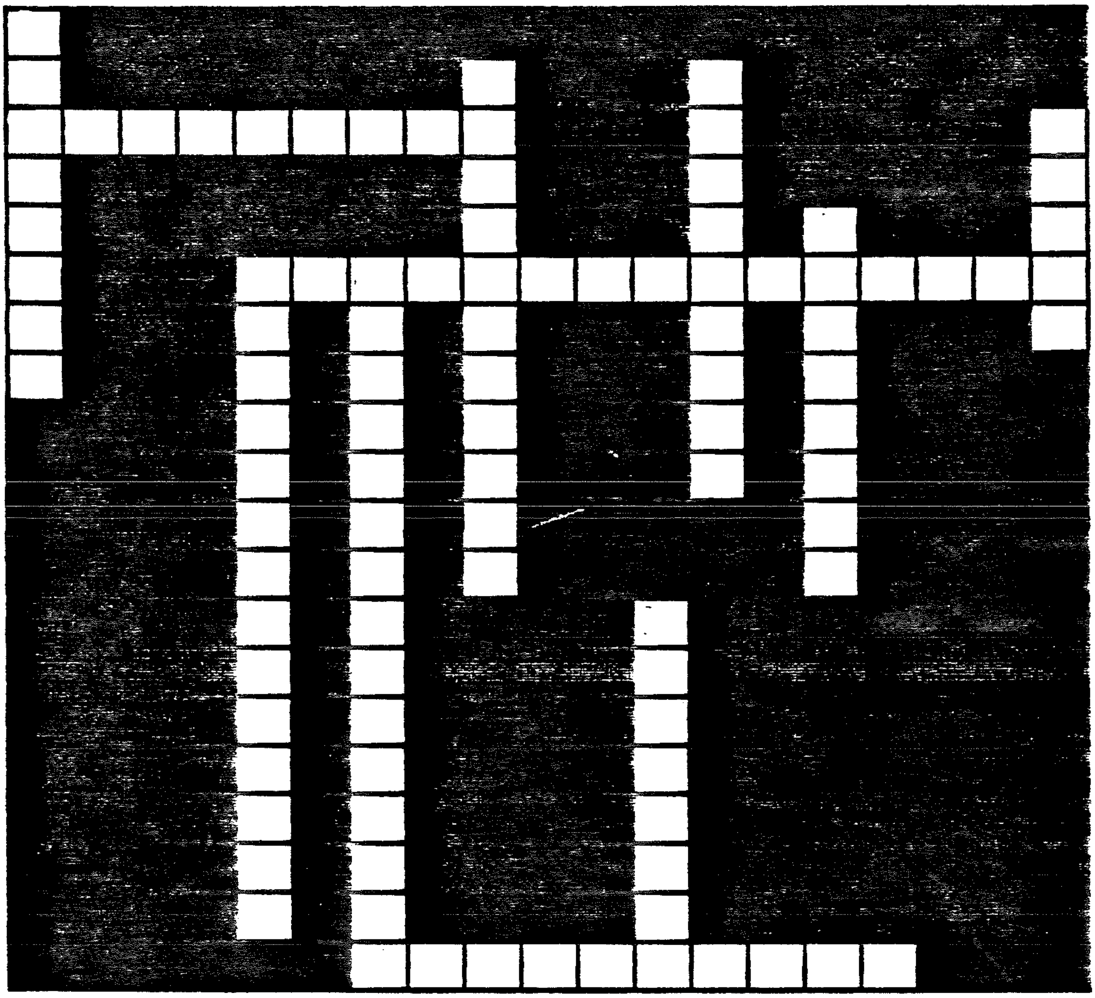
Appendices

Appendix A



TVAT MODEL CONSTRUCTION

shockcord
sheetdiecutfins
enginehook

nosecone
adapterring
launchlug
balsa
streamer
shockcordmount
enginemounttube
bodytube

ANSWER KEY

Across:

4. SHOCKCORD
7. SHEETDIECUTFINS
10. ENGINEHOOK

Down:

1. NOSECONE
2. ADAPTERRING
3. LAUNCHLUG
5. BALSA
6. STREAMER
7. SHOCKCORDMOUNT
8. ENGINEMOUNTTUBE
9. BODYTUBE

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N
O               A       L
S H O C K C O R D       A           B
E               A       U           A
C               P       N   S       L
O       S H E E T D I E C U T F I N S
N       H   N   E       H   R       A
E       O   G   R       L   E
        C   I   R       U   A
        K   N   I       G   M
        C   E   N           E
        O   M   G           R
        R   O         B
        D   U         O
        M   N         D
        O   T         Y
        U   T         T
        N   U         U
        T   B         B
            E N G I N E H O O K
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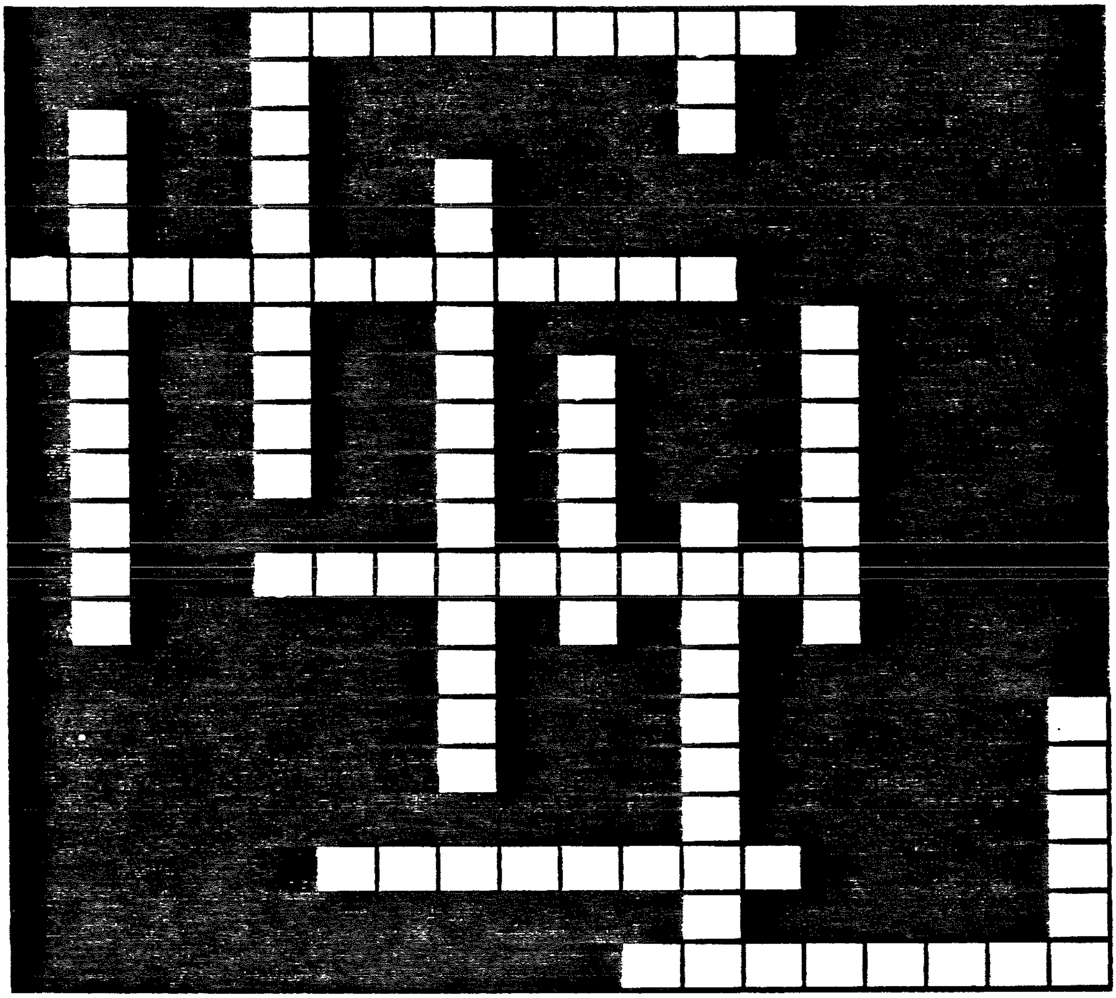

TVAT INFORMATIONAL I

COUNTDOWN
STARSPANGLED
SATELLITES
NITROGEN
REACTION

COMBUSTION
WWI
FORTMCHENRY
CONTROLCENTER
CHINESE
NOZZLE
ATMOSPHERE
SATURN

ANSWER KEY

Across:

1. COUNTDOWN
5. STARSPANGLED
9. SATELLITES
11. NITROGEN
12. REACTION

Down:

1. COMBUSTION
2. WWI
3. FORTMCHENRY
4. CONTROLCENTER
6. CHINESE
7. NOZZLE
8. ATMOSPHERE
10. SATURN

```
        C O U N T D O W N
        O             W
  F     M             I
  O     B     C
  R     U     O
S T A R S P A N G L E D
  M     T     T           C
  C     I     R   N       H
  H     O     O   O       I
  E     N     L   Z       N
  N           C   Z   A   E
  R     S A T E L L I T E S
  Y           N   E   M   E
              T       O
              E       S           S
              R       P           A
                      H           T
          N I T R O G E N         U
                      R           R
                    R E A C T I O N
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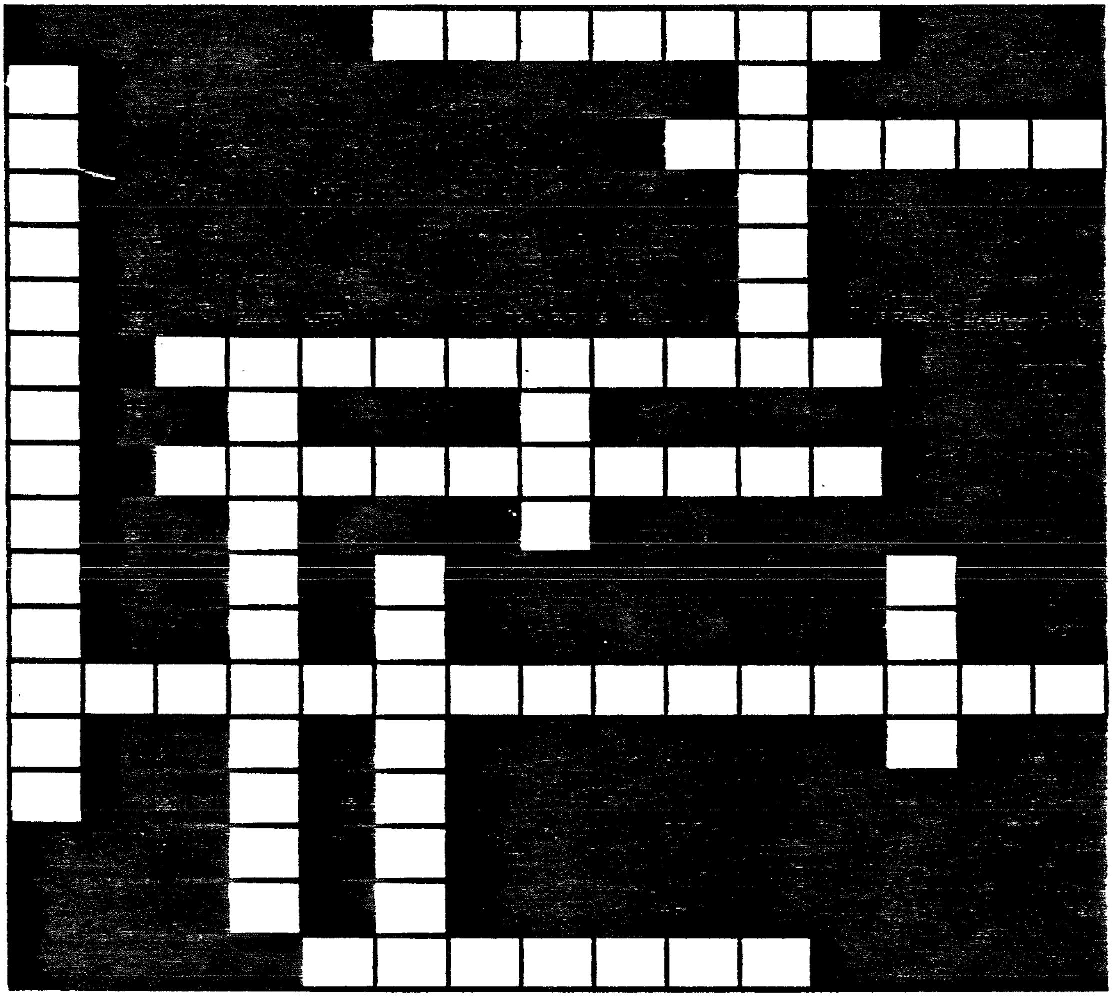

TVAT INFORMATIONAL II

BOOSTER
THRUST
LAUNCHSITE
PROPELLANT
TRACKINGSTATION
PROPELS

EXHAUST
SIRISAACNEWTON
AITFRICTION
HOLD
OXIDIZER
WWII

ANSWER KEY

Across:

1. BOOSTER
4. THRUST
5. LAUNCHSITE
8. PROPELLANT
11. TRACKINGSTATION
12. PROPELS

Down:

2. EXHAUST
3. SIRISAACNEWTON
6. AIRFRICTION
7. HOLD
9. OXIDIZER
10. WWII

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          B O O S T E R
S                   X
I                 T H R U S T
R                   A
I                   U
S                   S
A   L A U N C H S I T E
A     I       O
C   P R O P E L L A N T
N     F       D
E     R   O           W
W     I   X           W
T R A C K I N G S T A T I O N
O     T   D           I
N     I   I
      O   Z
      N   E
        P R O P E L S
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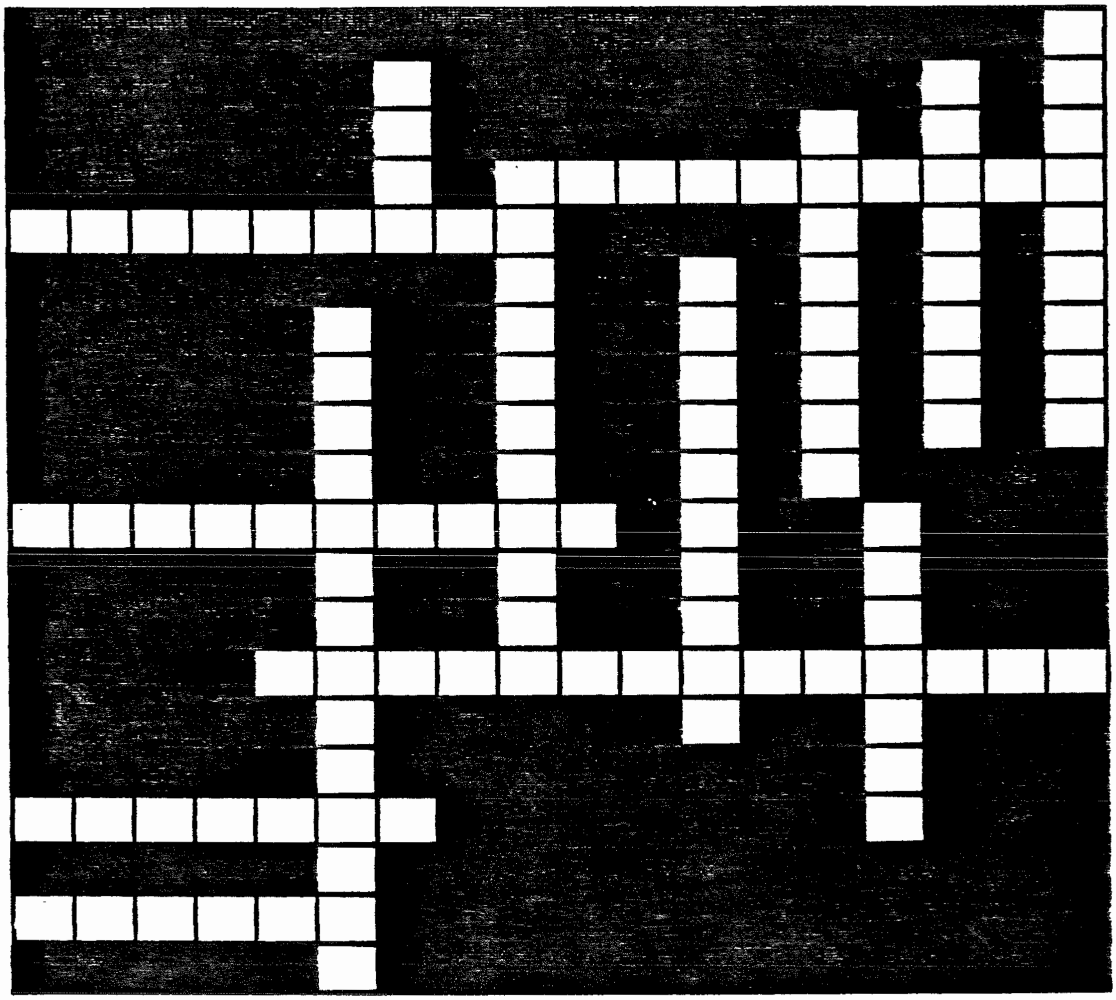

TVAT EXPERIMENTS

CONCLUSION
FORMULATE
HYPOTHSIS
COUPLINGDEVICE
GALILEO
ROTATE

BERNOULLI
DATA
FRICTION
QUESTION
CENTRIFICAL
MULTISTAGE
NULLHYPOTHESES
GRAVITY

ANSWER KEY

Across:

5. CONCLUSION
6. FORMULATE
9. HYPOTHESIS
11. COUPLINGDEVICE
12. GALILEO
13. ROTATE

Down:

1. BERNOULLI
2. DATA
3. FRICTION
4. QUESTION
5. CENTRIFICAL
7. MULTISTAGE
8. NULLHYPOTHESES
10. GRAVITY

```
                                  B
            D                 F   E
            A             Q   R   R
            T   C O N C L U S I O N
F O R M U L A T E         E   C   O
                N     M   S   T   U
          N     T     U   T   I   L
          U     R     L   I   O   L
          L     I     T   O   N   I
          L     F     I   N
H Y P O T H E S I S   S     G
          Y     C     T     R
          P     A     A     A
        C O U P L I N G D E V I C E
          T           E     I
          H                 T
G A L I L E O               Y
          S
R O T A T E
          S
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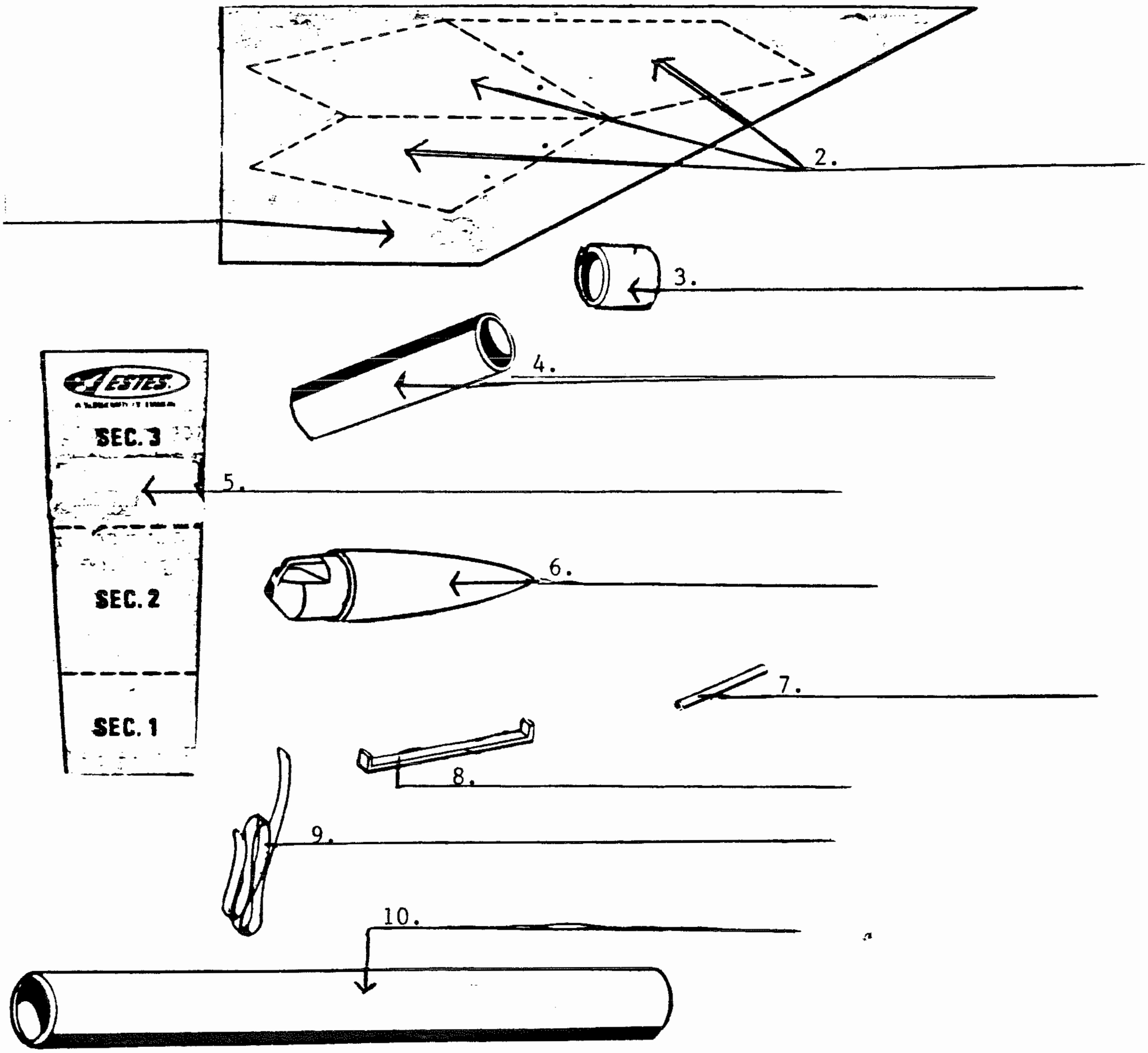
Appendix B

Rocketry Posttest 1

Model Construction



launch lug	shock cord	engine mount tube
nosecone	balsa	body tube
adapter ring	sheet die cut fins	shock cord mount
engine hook		streamer

11. The______________________are placed on the bodytube at 120° to provide for stability.

12. The______________________is glued over the engine mount tube to secure the engine hook tightly.

13. ________________________and the 14.______________________are made aerodynamic in order to cut through the atmosphere (air).

15. The root edge and the leading edge of the____________________ are important because they insure that all three parts will be glued on properly.

16. The____________________is lined up 10½ cm from the bottom of the tube and in direct line with the engine hook.

17. The____________________is elastic to absorb the shock of the charge that blows off the nosecone.

****

Bonus 2 - The engine hook is lined up with the______________________ on the body tube.

Bonus 5 pts. - There is a 1 cm slit cut on the engine mount tube. What is this for?____

Rocketry Posttest 2

Informational Materials

Star Spangled	combustion	propels
atmosphere	saturn	thrust
Fort McHenry	propels	Sir Isaac Newton's
satellites	nitrogen	propellant
nozzle	countdown	booster
reaction	air friction	hold
control center	launch site	tracking station
Chinese	oxidizer	exhaust
WWI		WWII

Informational Material Cloze Test

Rockets - World Book

1. The envelope of gases that surrounds the earth is the ______________________________________.
2. ______________________ is the burning of fuel like gasoline, kerosene, or liquid hydrogen.
3. The thrust of the engine is provided because the expanding gases are forced through the ______________________.
4. The rocket ______________________ forward, or is driven forward.
5. ______________________ law of motion is for every action there is an opposite and equal 6. ______________________.

7. The combined chemicals in the fuel, plus the oxidizer make up the____________________for the engine.

8. ____________________tetroxide is an example of an oxidizer. An oxidizer supplies oxygen to the combustion of the fuel.

9. The unbalanced pressure escaping out the nozzle produces a ________________or pushing force.

10. The largest rocket made for space travel was_________________.

11. ________________are an example of how rockets are used in research.

12. During the battle of__________________in the War 1812 is where the 13.________________Banner was written by Francis Scott Key.

14. The step by step process that prepares a rocket for launching is called a ____________________.

15. In the multistage rocket, the first stage is the____________.

16. In the first few minutes of a launch, the rockets speed is slowed down by________________________.

17. When there are poor weather conditions or when the launch process is stopped momentarily, this is called a______________.

18. The____________________directs the rockets flight.

19. The____________________records the path of the rockets flight.

20. The assembly buildings, launch pad, service structures, and control center all make up the___________________________.

21. Rockets used in war were first used by the____________in 1200's A.D.

22. The ________________________ supplies the oxygen that the fuel needs in order to burn.

23. The ______________________ is the gases escaping rapidly causing the rocket to be driven forward.

24. Explosive and ___________________ rockets were used in ______________ and 25. ___________________________.

Bonus 5 - Scientists use rockets for ____________________________ and ________________________ in the atmosphere and in space.

Rocketry Posttest 3

Experiments

scientific method	Galileo	null hypotheses
action-reaction	conclusion	friction
formulate	Bernoulli	multistate
data	centrifical force	coupling device
null hypotheses	gravity	rotate
question		

1. When an object is pushed with a certain force, it does not continue to move at the same speed but rather slows down and finally stops due to a resistance of the surfaces in contact. This slowing down and stopping is due to ________________________.

2. ___________________________ is an invisible force that pulls all objects to the earth.

3. A multistage rocket often has its engines joined together by a ________________________.

4. Satellites _________________________ around the earth in an orbit.

5. The scientific method has the following steps: first the _________ ___________________, then the 6. _________________________________, 7. _______________________ and finally the 8. _______________________.

9. During the observation ________________ is recorded or collected.

10. Your opinion, or prediction is called the ______________________ in an experiment.

11. Watching an experiment, called the ______________________ gives proof of the experiment. Data is taken to keep a record of what happened.

12. The large marble will <u>not</u> hit the tray before the small marble is an example of a ______________________.

13. All scientists test things with the______________________.

14. The final statement in an experiment that either proves or doesn't prove the hypotheses is the ______________________.

15. ______________________discovered that moving air has less pushing power on a surface it flows over than still air.

16. A branch of science that studies the effect of air (gases) molecules on moving surfaces is called ______________________.

17. The imaginary string that hold rockets in orbit around the earth is______________________.

18. ______________________put forward a theory in the 1590's that all objects are pulled to the earth at the same speed no matter what they weigh.

19. Tennis shoes have tread on the bottoms to produce______________ between the shoe and the floor.

20. You may go on a ride at an amusement park that spins around so fast you are plastered to its inside walls by________________. The floor may drop out and leave you hanging on the wall.

21. The air escaping from a balloon nozzle is the________________. The balloon taking off is called the 22.________________.

23. Two piles of books are covered with a sheet of paper. Blowing under the paper and between the books produces ______________ (more / less) pressure to the bottom of the paper. The paper caves in. This discovery was made by 24. ______________________.

25. A marble spins rapidly in a jar and climbs the jar's walls because of ______________________.

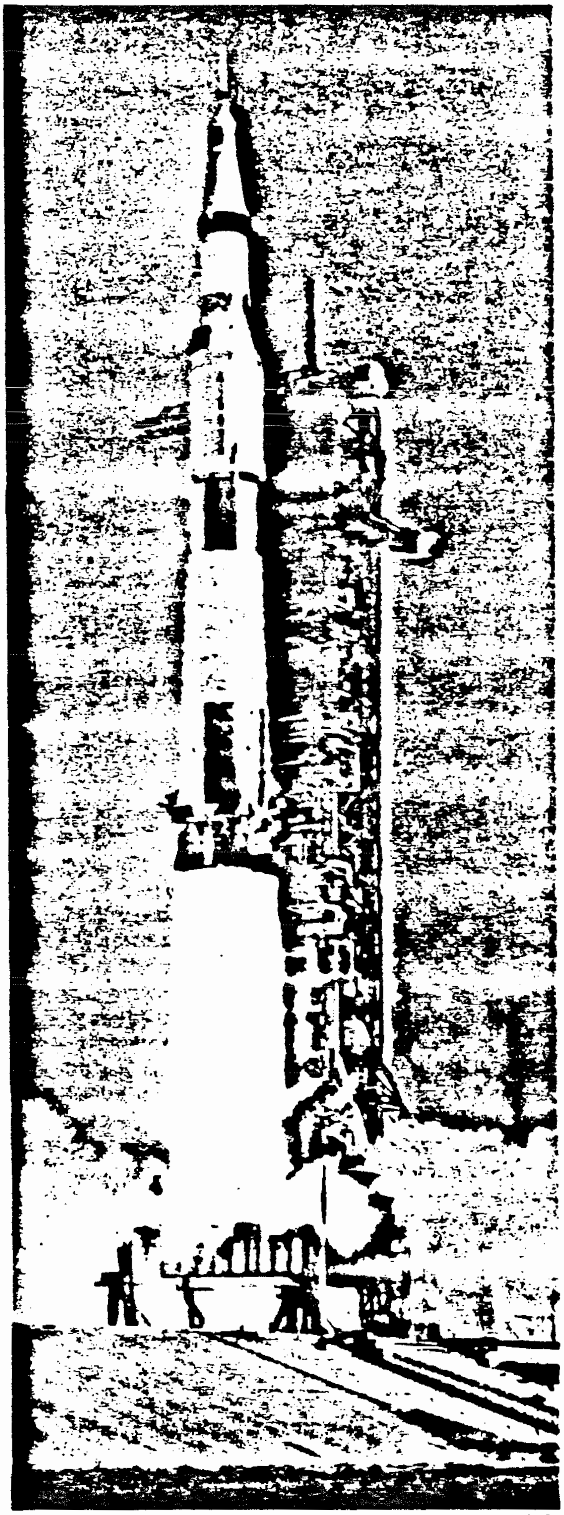
26. A rocket with two or more stages is called a ________________ rocket.

Bonus 5 - In order for a rocket to get out of orbit it must _________ ______________ its speed.

Appendix C

Informational Material

TVAT Sample



NASA

The giant Saturn 5 rocket that carried the first astronauts to the moon rises from its launch tower. Rockets are the only vehicles used for launching people and machines into space.

Rocket

Rocket is a type of engine that can produce more power for its size than any other kind of engine. A rocket can produce about 3,000 times more power than an automobile engine of the same size. The word *rocket* is also used to describe the vehicle driven by a rocket engine.

Rockets are made in a variety of sizes. Some of the rockets used to shoot fireworks into the sky are only 2 feet (61 centimeters) long. Rockets 50 to 100 feet (15 to 30 meters) long carry giant missiles that may be used to bomb distant enemy targets during wartime. Larger and more powerful rockets lift artificial satellites into orbit around the earth. For example, the Saturn 5 rocket that carried astronauts to the moon stood more than 360 feet (110 meters) high.

A rocket can produce great power, but it burns fuel rapidly. For this reason, a rocket must have a large amount of fuel to work for even a short period of time. The Saturn 5 rocket burned more than 560,000 gallons (2,120,000 liters) of fuel during the first 2½ minutes of flight. Rockets become very hot as they burn fuel. The temperature in some rocket engines reaches 6000° F. (3300° C), about twice the temperature at which steel melts.

People use rockets chiefly for scientific research, space travel, and war. Rockets have been used in war for hundreds of years. In the 1200's, Chinese soldiers fired them against attacking armies. British troops used rockets to attack Fort McHenry in Maryland during the War of 1812 (1812-1814). After watching the battle, Francis Scott Key described "the rockets' red glare" in "The Star-Spangled Banner." During World War I (1914-1918), the French used rockets to shoot down enemy airplanes. Germany attacked London with rockets during World War II (1939-1945). Today's rockets can destroy satellites in orbit around the earth as well as jet airplanes and missiles that fly faster than the speed of sound.

Scientists use rockets for exploration and research in the atmosphere and in space. Rockets carry scientific instruments high in the sky to gather information about the air that surrounds the earth. Since 1957, rockets have shot hundreds of satellites into orbit around the earth. These satellites take pictures of the earth's weather and gather other information for scientific study. Rockets also carry instruments far into space to explore the moon, the planets, and even the space among the planets.

Rockets provide power for human space flights, which began in 1961. In 1969, rockets carried astronauts to the first landing on the moon. In 1981, rocket power launched the first space shuttle into orbit around the earth. In the future, rockets may carry people to Mars and the other planets.

The contributor of this article, Warren C. Strahle, is Regents' Professor of Aerospace Engineering at the Georgia Institute of Technology.

"Rocket" (1991). World Book Encyclopedia

A basic law of motion—discovered in the 1600's by the English scientist Sir Isaac Newton—describes how rockets work. This law states that for every action, there is an equal and opposite reaction (see Motion [Newton's laws of motion]). Newton's law explains why the flow of air from a toy balloon *propels* (drives forward) the balloon in flight. A powerful rocket works similarly.

A rocket burns special fuel in a *combustion* (burning) chamber and creates rapidly expanding gas. This gas presses out equally in all directions inside the rocket. The pressure of the gas against one side of the rocket balances the pressure of the gas against the opposite side. The gas flowing to the rear of the rocket escapes through a nozzle. This exhaust gas does not balance the pressure of gas against the front of the rocket. The uneven pressure drives the rocket forward.

The flow of gas through the nozzle of a rocket is the *action* described in Newton's law. The *reaction* is the continuous *thrust* (pushing force) of the rocket away from the flow of exhaust gas.

Rocket propellant. Rockets burn a combination of chemicals called *propellant.* Rocket propellant consists of (1) a fuel, such as gasoline, kerosene, or liquid hydrogen; and (2) an *oxidizer* (a substance that supplies oxygen), such as nitrogen tetroxide or liquid oxygen. The oxidizer supplies the oxygen that the fuel needs to burn. This supply of oxygen enables the rocket to work in space, which has no air.

Jet engines also work by means of an action-reaction process. But jet fuel does not contain an oxidizer. Jet engines draw oxygen from the air and, for this reason, cannot function outside of the earth's atmosphere. See **Jet propulsion.**

A rocket burns propellant rapidly, and most rockets carry a supply that lasts only a few minutes. But a rocket produces such great thrust that it can hurl heavy vehicles far into space.

A rocket burns the most propellant during the first few minutes of flight. During that time, the rocket's speed is held down by air friction, gravity, and the weight of the propellant. Air friction drags on the rocket as long as the rocket travels through the atmosphere. As the rocket climbs higher, the air becomes thinner and the friction decreases. In space, no air friction acts on the rocket. Gravity pulls a rocket toward the earth, but the pull decreases as the rocket travels farther from the earth. As a rocket burns its propellant, the weight it must carry becomes less.

Multistage rockets consist of two or more sections called *stages.* Each stage has a rocket engine and propellant. Engineers developed multistage rockets for long flights through the atmosphere and for flights into space. They needed rockets that could reach greater speeds than were possible with single-stage rockets. A multistage rocket can reach higher speeds because it lightens its weight by dropping stages as it uses up propellant. A three-stage rocket can reach about three times the speed of a single-stage rocket carrying the same amount of fuel.

The first stage, called the *booster,* launches the rocket. After the first stage has burned its propellant, the vehicle drops that section and uses the second stage. The rocket continues using one stage after another. Most space rockets have two or three stages.

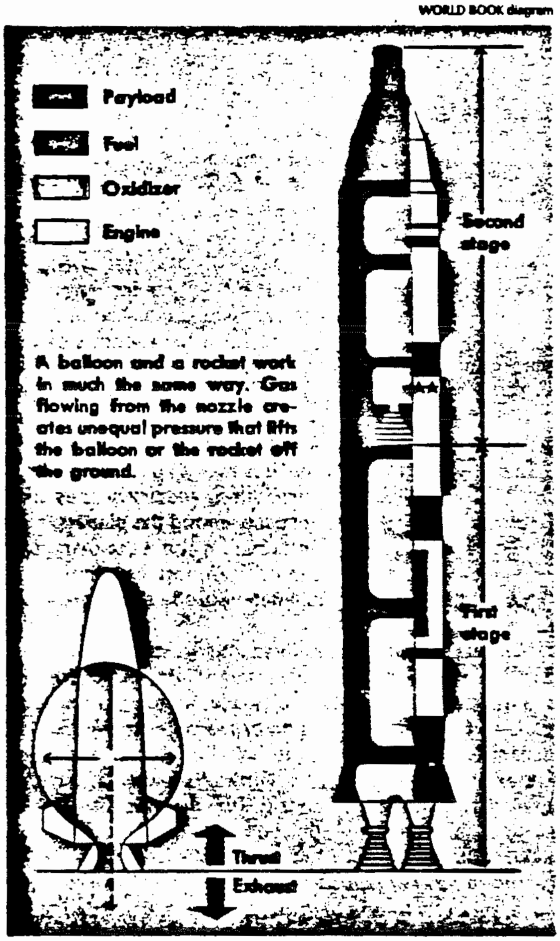
Launching a rocket. Space rockets require specially equipped launch sites. All launching activity at a site centers around the launch pad from which the rocket is fired. A launch site also has (1) assembly buildings, where engineers complete the final steps of rocket construction; (2) service structures, where workers check the rocket before launching; and (3) a control center, where scientists direct the launch and flight of the rocket. Tracking stations, located around the world, record the path of the rocket's flight.

Engineers prepare a rocket for launching in a step-by-step process called the *countdown.* They schedule each step for a specific time during the countdown and launch the rocket when the countdown reaches "zero." Undesirable weather or some other difficulty may cause a *hold,* which temporarily stops the countdown.

How a multistage rocket works

A two-stage rocket carries a propellant and one or more rocket engines in each stage. The first stage launches the rocket. After burning its supply of propellant, the first stage falls away from the rest of the rocket. The second stage then ignites and carries the payload into earth orbit or even farther into space.

WORLD BOOK diagram



Laws and Principles

Concerning Space Travel

Experiments

I. Action - Reaction

Multistage

1. Balloon Rockets

Question:

Hypothesis:

Procedure: Have about 20 feet of string and secure one end to a wall by tape. String two straws onto the string. Blow up a balloon to its maximum without breaking. Hold the nozzle while someone else tapes one straw to the side of the balloon. Let the balloon travel to the end of the string that is taped. How far did it go? Have someone stand by that spot.

Now, make a two stage rocket that contains a booster. Take one balloon and put it through a coupling device - the neck of a plastic bottle. Put the nozzle right at the end of the coupling device. Place the second balloon in the same position but pull it farther out so only the end is in the neck. Blow up the first balloon as far as it is possible without bursting. Hold the nozzle tight. Now blow up the second balloon as far as you can without it pulling out of the coupling device. Hold the nozzle of this balloon. Have someone attach the two straws to the balloon's sides, one straw for each balloon.

Place your balloon rocket at the end of the string and let it go. Observe how far it went.

II. Centrifical Force

1. Record Player

Question:

Hypothesis:

Procedure: Place a small object on a phonograph turntable at 33-1/3 speed and observe its motion. Try the same activity at 45 and 78 speeds.

2. Jar and Lid

Question:

Hypothesis:

Procedure: Screw on the top of a glass jar as tight as you can. Then, wet your hands and soap them up. Try to unscrew the lid.

V. Bernoulli

Air Stream

1. Books and Paper

Question:

Hypothesis:

Procedure: Make two stacks of large thick books with two books in each stack. Move them about 10 cm apart. Lay a sheet of paper over the books. Blow under the paper through the space between the books.

2. Paper and Paper

Question:

Hypothesis:

Procedure: Hold two sheets of paper together in front of your face. Make a small space between them. Blow between them.

3. Wing - Airplane

Question:

Hypothesis:

Procedure: Fold a piece of paper in half and tape the top half sheet about 2.5 cm from the edge of the bottom sheet edge. This will make the top sheet have a curve. Slide a ruler into the fold of the wing and out the other side. Blow over the curved top sheet of paper putting the fold and ruler at your bottom lip.

4. <u>Paper Darts</u>

Question:

Hypothesis:

Procedure: You'll need two pieces of paper about 30 cm x 20 cm. Take one piece of paper and try to throw it. Next, wad it up and then throw it. Now take the other sheet and make it into a paper dart.

I. Multistage: Action - Reaction

1. Balloon Rockets

Question:

Hypothesis:

Observation:

Conclusion:

II. Centrifical Force

1. Record Player

Question:

Hypothesis:

Observation:

Conclusion:

2. Ball and String

Question:

Hypothesis:

Observation:

Conclusion:

2. Jar and Lid

Question:

Hypothesis:

Observation:

Conclusion:

V. Bernoullis - Air Stream

1. Books and Paper

Question:

Hypothesis:

Observation:

Conclusion:

Appendix D

Raw Posttest Scores

Student #	Model Construction	Informational Materials	Experiments
301	67	50	56
302	93	87	101
303	100	76	79
304	105	101	92
305	85	81	88
306	105	103	105
307	105	90	100
308	108	106	105
309	105	89	105
310	80	46	61
311	108	93	97
312	80	86	98
313	87	98	101
314	98	81	89
315	76	38	85
501	105	106	101
502	76	82	101
503	94	82	85
504	93	68	101
506	94	86	80
507	98	91	76
508	88	59	92
509	100	94	89
510	82	64	81
511	88	80	88
512	87	86	89
513	93	86	105
514	105	97	96
515	82	77	81