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The Investment of Mental Effort on Learning Through Different Media

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THE INVESTMENT OF MENTAL EFFORT ON LEARNING THROUGH DIFFERENT MEDIA

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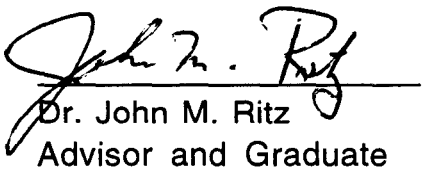
ARROVAL BY: 

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CHAPTER I

INTRODUCTION

The rise of new technologies and distance education have caused a change in the way instructional materials are presented to students. Instruction through video broadcast have become a widely accepted teaching tool in the educational environment. However, it is often claimed both by lay people and experts in the field of education that television somehow inhibits "deeper" processing of material and thus cannot serve well as an instructional medium (Salomon, 1984). This claim is built upon the belief that television viewing is a recreational activity and, therefore, the needed amount a mental effort is not invested to achieve learning.

This paper focuses on the mental effort invested by middle school students in learning through video. This knowledge may prove to be beneficial in determining the overall effectiveness of video broadcast instruction. The comparison of invested mental effort to achievement between video and print-text lessons will help instructional designers in the development of strategies to improve video broadcast instruction.

STATEMENT OF PROBLEM

This study sought to determine the level of achievement and mental effort fifth grade school children invested in learning content which was presented through print and video-based media. Through comparing video animation with print visualization material, this study should give instructional designers an additional source from which to consider in appropriating program expenditures to the development of instruction.

RESEARCH GOALS

The purpose of this study was undertaken for seven reasons:

1. To investigate the effects various media have on learner achievement on a test of recall and inference items. The three media forms consist of a print-text lesson, a print-text lesson that included visualization of some of the text content, and an instructional video lesson which included an animated segment of the content. (Factor A)

2. To examine the relationship between learner's preconception of learning from a specific medium (video or text) and achievement. (Factor B)

3. To examine the relationship between learners' perceived

mental effort in learning from text and video and achievement. (Factor C)

4. To investigate the effect of learners' abilities on achievement. (Factor D)

5. To explore the interaction between medium form (video or text) and learner's abilities on facilitating achievement. (Factor A x D)

6. To explore the interaction between learners' perceived mental effort to learn from a medium (video or text) and learner's abilities. (Factor C x D)

7. To explore the interaction between learner's preconception of mental effort on learner achievement. (Factor B x D)

BACKGROUND AND SIGNIFICANCE

The 1960's and 1970's saw an increase in the number of videotape recorders which gave teachers greater control over classroom television. Today, approximately three-fourths of all middle and secondary schools have at least one video-recorder (Corporation for Public Broadcasting, 1984), allowing greater

flexibility in playback times and the building of local tape libraries (Nugent, 1987).

Video provides for learners of different styles. There are "visual" or sight-oriented learners and "aural" or sound-oriented learners; some learn from reading, some from lectures. Because both visual and aural learners benefit from video instruction, it should be considered an essential educational medium (Torrence, 1985).

The National Aeronautics and Space Administration's (NASA) Office of Education plays an active role in designing and developing instructional video to assist teachers in educating their students. NASA depends on the U.S. education system to produce a skilled and knowledgeable workforce. The educational community, in turn, uses the aerospace program to motivate and encourage students to study science, mathematics, engineering, and technology (NASA's Strategic Plan for Education, 1992).

This research study arose from the development of a video broadcast designed to support NASA's Strategic Plan for Education. In creating an educational video production for middle school students, it was assumed that animation makes learning more "fun" and "interesting" for the students. Previous studies, however, have

indicated that the impact of video color imagery on cognitive experience has yet to be determined (Luskin, 1996).

LIMITATIONS OF THE STUDY

This study was limited to the gathering of results received from fifth grade, remedial students enrolled in summer school in Newport News, Virginia (see "Population", Chapter III). The intent of the tests and questionnaires was designed to gather information that was relevant to one video program.

BASIC ASSUMPTIONS

It was assumed in this study that the video program contained content at the learning and understanding level of fifth grade school children and that the tests administered to measure learning were relevant to that content and written at grade-appropriate level.

PROCEDURES

A preliminary trial of the research study (pilot) was conducted by the administration of a pre-test and then an immediate post-test to two fifth grade classes. One fifth grade class (control group) served as the uninstructed class, while the second class served as

the experimental group. The control group received the pre-test on preconception of mental effort and prior knowledge (see Appendix B). The experimental group were asked to answer the same pre-test, view the video "*Think Bigg*", and immediately take the post-test. The pilot study allowed the researcher to: (1) ascertain whether the students learned from the video; (2) determine the congruence of the test with instruction; (3) perform an item analysis on the test items; and (4) make necessary item revisions.

The data for the main research study were collected by administration of the pre-test and two post-tests to two fifth grade classes. The results of the prior knowledge section of the pre-test determined the ability level of the participants (at least three correct of five questions = high ability). One-third of the high ability students then were randomly assigned to each treatment group (print-text, text with visual, and video). A comparison of the data identified differences in learning achievement (post-test) between students randomly assigned to one of three treatment groups: print-text, print-text with still visualization, and video-based program with animation. A questionnaire was included in the pre-test to assess students' preconceptions to the ease of learning from text and video. A questionnaire was also added to the post-

test to determine perceived mental effort investment in learning the content from a specific medium by students.

DEFINITION OF TERMS

The following terms were used in this study:

1. Mental Effort Investment. The number of nonautomatic mental elaborations applied to learning material (Salomon, 1984).

2. Print-text Visualization. Textual-based content with a section presented in a cartoon format.

3. Video-based Instruction. An instructional program produced, in advance, for subsequent viewing by students. The visual portion of a televised broadcast (Webster's II, New Riverside University Dictionary, 1994).

OVERVIEW

Chapter I presented an introduction and the problem of this study. It discussed the research goals as well as the background and significance regarding the problem. Also discussed in this chapter were the limitations, basic assumptions, procedures used in data collection, and the definitions that were important to understanding the terms used by the researcher.

Chapter II reviews the literature regarding other research conducted relative to the problem under investigation. Chapter III describes the methods and procedures for data collection, including the design of the pre-test, post-test, questionnaire and their implementation. Chapter IV reports the findings of the data collected. Chapter V describes the summary, conclusions, and recommendations that resulted from the study.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this chapter was to review the literature that was related to the objectives of this study. Contained within this chapter were sections on video-based and print-based instruction, and the perceived mental effort required to achieve learning.

LEARNING THROUGH TELEVISION

There have been many studies comparing video-based and print-based media as instructional methods and their effectiveness on learning. Clark (1983) stated that media are mere vehicles which deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition. Therefore, further investigation into learning achievement through different media should be reconsidered. Those who have accepted Clark's conclusion agree that there is no compelling evidence in the past 70 years of research that media cause learning increases (Clark, 1994).

Kozma (1991) suggested that the position of media not influencing learning should be changed. He suggested that television, in several different ways, may affect cognitive

structures and processes. As with books, television can employ pictures, diagrams, and other representational symbol systems, but, in television, these symbols are transient and able to depict motion. In addition, television can present auditory and visual symbol systems simultaneously.

In studies conducted by Baggett (1979), it was found that meaning can be conveyed by either symbol system. When presented together each source provides additional, complementary information that retains some of the characteristics of the symbol system of origin. The visual component of the presentation is particularly memorable, and the representations constructed with it are especially good for carrying information about situations. It is possible that the symbol systems used and their transient nature affect the mental representations created by television.

Research by Salomon (1984) investigated whether television and print are two possible sources of information about which children are likely to have differential perceptions and expectations concerning the mental effort needed for satisfactory processing, even when the same kind of material is presented. Television is more often perceived to be intended to entertain and to serve escapist functions, whereas print is perceived to inform and

educate. Salomon suggests that learners perceive television as easier than print and report investing less mental effort in learning from video. He also concluded that the learner's perception of video as being an "easy" medium influenced the amount of invested mental effort which the learner applied to the video-based instruction, and, consequently, resulting in lower achievement scores over print-based instruction. The learner's perceptions about a medium and the purposes he or she has for viewing influence the amount of effort that is put into the processing of the message, and, consequently, the depth of understanding.

Cennamo (1993) has built upon the series of studies completed by Salomon. She explored factors that influenced learners' preconceptions of television, the mental effort they invest in processing a video-based lesson, and their achievement. It was proposed that learner's preconceptions of the effort required by a medium directly influences the amount of effort they invest in processing a lesson presented through that medium, and that the amount of mental effort learners invest in a mediated lesson influences the quantity and quality of the information they gain from the lesson. The factors that influence learners' preconceptions and

mental effort included the characteristics of the medium, the characteristics of the task, and the characteristics of the learners.

The strengths of video/television can often be a limitation to some learners. Learner characteristics such as aptitude, motivation, oral comprehension, and prior knowledge have great impact on the effectiveness of video (Kozma, 1991). The usefulness of video for learning purposes has been identified by Kozma (1991). He states that the strengths of learning with video are: efficiency of conveying information to a large group in a short period of time, ability to use auditory and visual channels at the same time, and that comprehension of video seems driven by visual information. However, the usefulness of video is decreased by these limitations; video pace is not sensitive to cognitive demand on the viewer, video is perceived to be easier than print which requires less investment of mental effort into learning; shallow processing, and discontinuous, periodic attention is given by the viewer, who is not able to go back and review when a difficult concept is presented.

MENTAL EFFORT INVESTMENT

The idea that the investment of effort in processing improves learning is not new. Many researchers have employed the idea of

effort as a hypothetical construct to explain learning and performance differences. For example, Bandura (1982) related the construct of sustained effort to differences of perceived self-efficacy and to performance. The more one believes in one's ability to perform a task, the more he/she is likely to invest sustained effort in performing it.

The mental effort investment reflects both cognitive and motivational attributes. However, mental effort investment and motivation are not to be equated. Motivation is the driving force, but for learning to actually take place some specific relevant mental activity needs to be activated. This activity is assumed to be the employment on nonautomatic effortful elaborations. Being motivated to recall material, one would need to generate mnemonics and to conjure images. Being motivated to comprehend the material, one would need to elaborate in one's mind. Motivation is probably the driving force for the expenditure of effort in such mental activities, but it is the effort-demanding activities that produce better recall, comprehension, or inference-making (Salomon, 1982).

LEARNING FROM PRINT

Kozma (1991) describes print as a medium that can be characterized by the symbol systems it can employ, i.e., text and pictures. The learners build a model of the situation described with information from the text-base and schemata activated in long-term memory. They slow down to comprehend difficult or important points, and stop, or regress, to retrieve the meaning of an unfamiliar work or a confusing clause or sentence. In less familiar domains, the readers will move back and forth frequently between text and picture to clarify the meaning of a work or to construct or elaborate on a model of the situation. Kozma (1991) concludes that some students will learn a particular task regardless of the delivery device; others will be able to take advantage of a particular medium's characteristics to help construct knowledge. The learner's characteristics dictate some limitation to the usefulness of print-text material.

SUMMARY

In general, the review of media research (Clark, 1983; Clark and Salomon, 1986; Kozma, 1991; Cennamo, 1993) suggests that media do not affect learning in and of themselves. Rather, some

particular qualities of media may affect particular cognitive processes that are relevant for students with specific aptitude levels to learn particular knowledge or skills.

Chapter II reviewed the literature of other research conducted relative to the problem under investigation. Chapter III presents the methods and procedures used in developing the tests and processing the results.

CHAPTER III

METHODS AND PROCEDURES

The purpose of this chapter was to explain the testing and questionnaire procedures used to obtain data for this research study. The data was obtained from fifth grade students from the Newport News Public School System. In subsequent chapters, the data was interpreted to determine the learner's preconception of difficulty and perceived investment in learning from television or print and the effect on achievement measures. Of further interest was the contribution of the learner's ability level (prior knowledge; high/low) on each of the factors and to learning (achievement) from a specific medium. Achievement was measured by three criterion tasks -- knowledge (facts, concepts), comprehension, and application. Discussed in Chapter III were population, instrument design, methods of collecting data, and statistical analysis.

POPULATION

Participants of this research study were fifth grade students from Newport News, Virginia. This study included a sample of forty-six students enrolled in a summer enrichment program. The students were recommended to the enrichment program by their

fifth grade, fall/spring semester, teacher because they were working below fifth grade level, although not to the extent to be retained. All forty-six participants were volunteers. Parental permission and signed consent forms were obtained from each participant. A sample of the informed consent form is included in Appendix A.

INSTRUMENT DESIGN

Three instruments were designed for purposes of this study: a pre-test to identify the preconceptions of the amount of mental effort invested to learn from a medium, to include a section to test the students prior knowledge, an achievement test, and a mental effort questionnaire. Students responded on a 4-point Likert scale for each questionnaire, with 1 representing "low" and 4 representing "high".

The preconception questionnaire (pre-test) included eight questions pertaining to students' preconceptions of the ease or difficulty of learning through the video versus print medium. The questions asked the following four questions for preconception of learning through video and print-text mediums:

- How difficult would it be for you to learn to solve a math problem from [medium]?
- How difficult is it to concentrate on material from [medium]?
- How difficult is it to remember how to play a game from [watching/reading] the directions?
- How difficult is it to recall details after [watching/reading] a lesson?

Appendix B contains a sample of the pre-tests. The responses guided the researcher in assessing the students attitudes towards each medium of instruction.

The learner's prior knowledge of the learning content was used to separate students into "high" ability and "low" ability groups. The results were assessed through a five-item prior knowledge section included on the preconception questionnaire (pre-test) administered one week before implementation of the treatment. Identical immediate and delayed post-tests (achievement) were run directly following the treatment to determine the level of original learning and one week later (delayed) to determine retention by the learner of the instructional material (Appendix C).

Mental effort was assessed through a self-report questionnaire which asked them to estimate the amount of mental

effort that they had invested in processing the lesson. The questionnaire consisted of six items that were derived from the questions that Salomon used in two studies (1983b,1984). Students were asked to rate their responses to questions such as:

- How hard did you have to concentrate while [watching/reading] the lesson in order to learn from the [medium]?
- How much did the [medium] lesson make you think?
- How hard did you try to understand the [medium] lesson?

The post-test questionnaires are found in Appendix C.

The information for the study were obtained through a multiple choice pre-test and post-test design. A sample of the pre-test and post-test also has been included in Appendix C.

The instructional strategy used in the lesson design followed the events of instruction -- gain attention, stimulate recall, present stimulus, provide learning guidance, and enhance retention and recall -- outlined by Gagné and Briggs (1992).

METHODS OF COLLECTING DATA

This research study consisted of two phases, a pilot phase and a main phase. The purpose of the pilot was for the investigator to inspect the validity of the pre-test and post-test. By examining the

results of the questionnaire (pre-test) and mental effort and achievement (post-test), the investigator was able to validate the testing instruments.

The pilot study was implemented in May 1996 with two fifth grade classes (n = 19) from the Hampton City School system. Students were considered "average" fifth grade level students and did not participate in enrichment programs. One class (n = 9) served as the control group, which answered a questionnaire with five prior knowledge and three preconceptions of mental effort items. A second class (n = 10) served as the experimental group, received an identical questionnaire, followed by the video presentation (treatment), and then immediately received a post-test with five achievement and three mental effort assessment items.

The main study consisted of two fifth grade classes (n = 46) from the Newport News Public School System. Pre-tests were administered to students at the summer school they attended in July 1996. Written directions and a trained facilitator were available for the students. Students were then randomly assigned to each treatment group (see Table 4.1).

The manner in which the events of practice and feedback were presented in the three lessons constituted the primary difference

among the three treatments. The two text-based lessons contained practice and feedback, but due to the characteristics of the medium the response to the practice questions were presented immediately following the practice questions. This differed from the video-based lesson where the learner was presented with the practice item and then had response time of five to seven seconds built into the program. The response time gave students the opportunity to respond covertly to the practice items before seeing the answer. The feedback on the video lesson remained on the screen five to seven seconds and in some cases flashed several times.

All students completed a pre-test on the lesson content and completed a preconceptions questionnaire one week before the treatment. Based on pre-test results, students were divided into two groups: high- and low-ability. Students, once identified into ability groups, were randomly assigned to treatments. One-third of all the high- and low-ability students were randomly assigned into each treatment group.

After completing the lesson, students were instructed to complete a questionnaire on mental effort. All three treatments were immediately assessed with an immediate print-based post-test that contained identical achievement items presented in the

pre-test. The delayed post-test contained the same achievement questions as the pre-test and immediate post-test. The delayed test was administered one week after the treatment.

Students assigned to the video treatment group saw the video once. The length of the video was approximately thirty-five minutes. The students assigned to the two print-text treatments were told to read through the lesson once, but were told they had as much time as they needed to complete the reading. The print-text lesson was an edited script that was developed for the video program, *"Think Bigg"*. The print-text with visualization was the same script with a section of the content presented in a cartoon format. This cartoon section is equivalent to the animated section of the *"Think Bigg"* video program. Copies of the print-text and print-text with visualization materials are included in Appendix D. A copy of the *"Think Bigg"* video is an addendum to this study and can also be obtained through the Office of Education at NASA Langley Research Center.

STATISTICAL ANALYSIS

Questionnaire data were compiled by the researcher so that it could be determined how the students perceived the ease or

difficulty of the medium through which the lessons were presented. The data was also used to rate the amount of mental effort the learner invested in processing the lesson. Closed form achievement questions drew responses which included information explicitly stated in the lesson as well as inferences connecting ideas that were presented in the lesson.

Data was organized and then analyzed using a t-test, paired two-sample for means, and a t-test, two-sample assuming unequal variance. The data focused on students' preconception of the ease or difficulty of learning through different mediums, the mental effort invested in learning, and achievement through recall and retention of the content.

SUMMARY

The sample of the population, instrument design, instrument administration, and statistical analysis permitted the researcher to collect data pertaining to the preconceptions of difficulty and mental effort invested in televised instruction. In Chapter IV, findings that resulted from the collection of data were further analyzed.

CHAPTER IV

FINDINGS

The purpose of this chapter was to examine the resultant data collected through the pre- and post-tests. Written explanations and tables were presented based on data collected from the tests. The data collected from the pre- and post-tests were to be used to answer the following objectives:

1. To investigate the effects various media have on learner achievement on a test of recall and inference items. The three media forms consist of a print-text lesson, a print-text lesson that included visualization of some of the text content, and an instructional video lesson that included an animated segment of the content. (Factor A)
2. To examine relationship between learner's preconception of learning from a specific medium (video, text) and achievement. (Factor B)
3. To examine the relationship between learner's perceived mental effort in learning from text and video and achievement. (Factor C)
4. To investigate the effect of learner's abilities on achievement. (Factor D)

5. To explore the interaction between medium from (video or text) and learner's abilities on facilitating achievement. (Factor A x D)

6. To explore interaction between learner's perceived mental effort to learn from a medium (video, text) and learner's abilities. (Factor C x D)

7. To explore interaction between learner's preconception of mental effort on learner achievement. (Factor B x D)

Thirty-eight of forty-six students, completed all phases of the research study. Eight students were removed at the end of the study due to their absence in one or more of the phases. Table 4.1 shows the revised number of students per treatment group. The number per treatment cell ranged from 2 to 14.

Table 4.1: Students per Treatment Cell

	High Ability	Low Ability	**Total**
Text	4	8	12
Text with Comic	2	10	12
Video	2	12	14
Total	8	30	38

RESULTS

The dependent measure was the perceived mental effort and achievement from learning content through print and video-based material. The data used for statistical analysis was collected from administration of the pre-test and post-tests. The pre-test was administered one week before the treatment; the post-test was administered immediately following the treatment; and the delayed post-test was administered one week following the treatment.

Table 4.2 summarizes the pre-test of preconception of ease or difficulty in learning from print and video means and standard deviations from the thirty-eight students who completed all phases of the study. The mean score for the preconception of the difficulty

in learning content from a video appears greater among the text treatment group. The preconception of difficulty of learning content through print was greater among the video group. A combined mean for all media groups showed that it was perceived more difficult to learn from video than print-text lessons. The t-value when compared to the t-critical value showed no significant difference (text, text/comic critical t = 1.79 and video critical t = 1.77).

Table 4.2: Means and Standard Deviations of Preconception of Mental Effort of Learning Difficulty through Video and Print.

Media	*Video* (max. score = 16)[a]			*Print* (max. score = 16)			Video/print combined (max. score = 32)			t*
	n	M	SD	*n*	M	SD	*n*	M	SD	
Text	12	8.58	3.05	12	8.25	2.98	12	16.8	5.3	.41
Text/Comic	12	7.83	1.85	12	7.66	2.93	12	15.8	2.26	.05
Video	14	8.07	1.77	14	8.92	1.81	14	17	2.54	1.2
All Media	38	8.42	2.6	38	8.05	2.2	38	16.5	3.55	

*p<.05
**one tail

Table 4.3 shows the means of the preconception of mental effort and the mental effort investment students reported on the immediate and delayed post-test for each treatment group. The video group means for each test phase are higher when compared to the text with comic group indicating greater amount of invested mental effort. However, the video and text with comic groups

[a]The greater the score, the greater the perceived difficulty.

perceived having invested more mental effort on the delayed post-test then they perceived investing immediately after treatment. The t-test between the immediate and delay self-reports of mental effort for each treatment group is shown on Table 4.4. Even though the means indicate an increase in perceived mental effort investment, there is no significant difference in the change.

Table 4.3: Means of Preconception, Immediate, and Delayed Mental Effort Investment Among Treatment Groups.

Media	*Preconception* (max. score = 32)		*Immediate*		*Delayed*	
	n	M	*n*	M	*n*	M
			(max. score = 12)		(max. score = 12)	
Text	12	16.8	12	8.75	12	8.58
			(max. score = 28)		(max. score = 28)	
Text/Comic	12	15.8	12	13.41	12	13.75
			(max. score = 28)		(max. score = 28)	
Video	14	17	14	14.92	14	15.78

Table 4.4: t-test between Immediate and Delay Mental Effort Paired Two Sample Means of Each Treatment Group.

Media	*Immediate*		*Delayed*		t *	t Crit
	n	M	*n*	M		
Text	12	8.75	12	8.58	.34	1.79
Text/Comic	12	13.41	12	13.75	-0.28	1.79
Video	14	14.92	14	15.78	-0.92	1.77

*p<.05
**one tail

Table 4.5 presents the descriptive statistics for the three media groups shown as the three independent variables: text, text with visual (comic), and video groups. The maximum score students could score for achievement was five. The mean score appeared to

increase from pre-test through delayed test for two groups (text, text/comic). The mean score for the third treatment (video) increased from pre-test (prior knowledge) to the immediate post-test (achievement), then showed a slight decrease (-.22) from the immediate post-test to the delayed post-test (retention).

Table 4.5: Means and Standard Deviations of Prior Knowledge and Achievement.

Media	*Prior Knowledge*			*Immediate*			Delayed		
	n	M	SD	*n*	M	SD	*n*	M	SD
Text	12	1.75	1.28	12	1.83	1.19	12	2.1	1.79
Text/Comic	12	1.41	.9	12	1.66	.98	12	1.83	1.19
Video	14	1.42	.85	14	1.57	.75	14	1.35	.93
All Media	38	1.52	1	38	1.68	.96	38	1.76	1.32

Table 4.6 was the calculated t-test values for the three treatments and pre- and post-test means shown in Table 4.5. Two of the three independent variables were compared for each treatment group to calculate the t-value. It was observed that there was no significant difference between the prior knowledge and achievement scores.

Table 4.6: t-Test: Paired Two Sample for Means of Prior Knowledge and Achievement.

Media	*Prior Knowledge/ Immediate*		*Immediate/ Delayed*		*Delayed/ Prior Knowledge*	
	t *	t crit**	t *	t crit**	t *	crit**
Text	-0.24	1.79	-1.17	1.79	-1	1.79
Text/Comic	-0.6	1.79	-0.43	1.79	-0.96	1.79
Video	-0.52	1.77	1.14	1.77	.26	1.77
All Media	-0.82	1.68	-1.12	1.68	-1.12	1.68

* p<.05
**one tail

Table 4.7 shows the assignment of the 38 students into treatment groups. The group means changed across the three tests. Students in the text with visual (comic) showed the greater overall change of +.42. Students assigned to the video treatment displayed a loss (-.22) in retention over time (one-week). No other treatment group showed a negative change. To identify where the changes occurred, Table 4.8 shows the means for the ability groups within each treatment and the achievement changes. A decrease in two high ability groups was observed (text -.25, text with comic -1.5) between the test of prior knowledge and the achievement delayed post-test.

Table 4.7: Media Means and Achievement Changes

	Pre-test	Post-test	Delayed	Change
Text (N = 12) (Mean)	1.75	1.83	2.1	+.35
Text/ Comic (N = 12) (Mean)	1.41	1.66	1.83	+.42
Video (N = 14) (Mean)	1.42	1.57	1.35	-.22

Table 4.8: Media Means and Achievement Changes between Ability Levels.

	Pretest	Posttest	Delayed	Change
Text High Ability (n = 4)	3.25	3.5	3.0	-.25
Text Low Ability (n = 8)	1.0	1.5	1.75	+.75
Text/Comic High Ability (n = 2)	3.0	1.5	1.5	-1.5
Text/Comic Low Ability (n = 10)	1.1	1.7	1.9	+.8
Video High Ability (n = 2)	1.5	1.5	2	+.5
Video Low Ability (n = 12)	1.16	1.58	1.25	+.09

A t-test assuming unequal variances was used when the number of students assigned to each treatment cells are unequal. Table 4.9 depicts the preconception of mental effort, immediate, and delayed tests between high- and low-ability groups. Table 4.10

indicates the t value between high- and low-ability for each test phase. A significance is identified between the ability groups in the post-tests. Indicating a significant difference between students' ability and the way they perceived the amount of invested mental effort.

Table 4.9: Means and Standard Deviations of Preconception of Mental Effort, Post-test Mental Effort Investment and Learners' Ability.

Ability	*Preconception* (max. score = 32)[b]			*Immediate* (max. score = 28)			*Delayed* (max. score = 28)		
	n	M	SD	*n*	M	SD	*n*	M	SD
High	8	17.75	2.12	8	11.57	4.5	8	9.5	2.7
Low	30	16.23	3.8	30	12.7	3.9	30	7.03	1.8
High/Low	38	15.85	5.0	38	11.73	4.05	38	7.55	2.88

Table 4.10: Means, Standard Deviations, and t-test of Learners' Ability and Preconception and Post-tests on Mental Effort.

Mental Effort	*High Ability*			*Low Ability*			*t**	*t Crit***
	n	M	SD	*n*	M	SD		
Preconception	8	17.75	2.12	30	16.23	3.8	1.48	1.72
Immediate	8	8.12	2.16	30	12.7	3.9	-3.16	1.68
Delayed	8	9.5	2.7	30	7.03	1.8	2.37	1.83

*p<.05
**one tail

Table 4.11 indicated the t-test of the paired sample means of the achievement post-tests within each ability group. The maximum

[b] The greater the score, the greater the perceived mental effort.

number correct was five. It was observed that the high ability groups' mean increased (.37), and the low ability groups' mean remained the same. However, the t-test indicated no significant difference between the immediate and delayed post-test for each ability group. Table 4.12 reverses the means and standard deviations of Table 4.11 to compare high- and low-abilities with learners' achievement. No significant difference was identified between ability level and achievement.

Table 4.11: Means and Standard Deviation of Achievement Post-tests and Learner's Abilities.

Ability	*Immediate*			*Delayed*			t *	t Crit**
	n	M	SD	*n*	M	SD		
High	8	2	1.06	8	2.37	1.50	-1.42	1.89
Low	30	1.6	.86	30	1.6	1.24	0	1.69

*p<.05
**one tail

Table 4.12: Means, Standard Deviations, and t-tests of Achievement Post-tests and Learners' Abilities.

Post-Test	*High Ability*			*Low Ability*			t *	t Crit**
	n	M	SD	*n*	M	SD		
Immediate	8	2	1.06	30	1.6	.93	.96	1.81
Delayed	8	2.37	1.50	30	1.6	1.24	1.33	1.81

*p<.05
**one tail

SUMMARY

The three independent variables, text, text with visual, and video lesson content, were considered separately and interactively in analysis of the resultant data collected through the pre- and post-tests. The dependent variables were preconception mental effort and achievement. These variable were examined within the ability levels of the participants. The ability levels were identified through the number of correct answers indicated on the prior knowledge section of the pre-test. This information was presented in written explanation and table form. A summary of the findings, conclusions, and recommendations as a result of those findings is presented in Chapter V.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter reported the summary of this study, the conclusions, and the recommendations as a result of the research data obtained from the pre- and post-test given to fifth grade students in Newport News, Virginia, in 1996. The results were to be used to assist the National Aeronautics and Space Administration's Office of Education in designing effective video broadcast programs.

SUMMARY

This study investigated learner's preconception mental effort and achievement on learning through print-text, print-text with visual, and video mediums. Chapter I presented an introduction and the problem of this study. It discussed the research goals and background and significance regarding the problem. Also, discussed were the limitations, basic assumptions, procedures used in data collection, and the definitions that were important to understanding the terms used by the researcher.

Chapter II reviewed the literature of other research conducted relative to the problem under investigation. Chapter III presented the methods and procedures used in developing the tests and

processing the results. Chapter IV presented the explanation of the resultant data collected from the testing process.

The instructional strategies were examined for their effect on mental effort invested on the presented information toward the acquisition and retention of knowledge. Data collected was relevant, reliable, and provided answers to the research goals of this study.

CONCLUSIONS

This study was based on the premise that learners' preconceptions of a medium may influence the amount of mental effort they invest in processing lesson content. Hence, the amount of mental effort learners' invested in processing a lesson may influence their achievement.

The outcome of the testing process revealed a number of consequential findings. (1) The investigation of the effects of various media on learners' achievement showed no significant difference between the three treatment groups. However, it was evident that the preconception of difficulty influenced the amount of mental effort students invested in learning from different media. In this study students who reported a preconception of medium as

"difficult" did not invest the amount of mental effort needed to achieve recall and retention.

(2) Examination of the relationship between learners' preconceptions of learning from a specific medium and achievement showed if the medium was perceived as "easy", they invested more mental effort to achieve learning. These findings differ from those of Salomon (1984) in which students perceived learning from television as "easy" and learning from print "difficult". His conclusions were attributed to the possible implication that television viewing was a recreational activity. In this study, the researcher attributed the findings to the lower ability levels of the participants enrolled in the enrichment program.

(3) The examination of the relationship between learners' perceived mental effort and their learning achievement also differed from those of Salomon (1984) in which he reported the students who perceive learning more difficult through a particular medium, scored higher on achievement test. This is shown in the video group who perceived learning more difficult and demonstrated a decrease of -.22 on achievement (Table 4.7).

(4) The investigation of the effect of learners' abilities on achievement revealed a decrease in two high-ability groups (text -

.25, text with comic -1.5) indicating ability levels had no significant difference from low-ability students on achievement. These findings are attributed to high-ability students were able to "guess" more correct answers on the prior knowledge pre-test.

(5) The findings for the interaction between medium form and learners' abilities on facilitating achievement indicated no significant difference. Table 4.8 showed the text medium where high-ability students maintained a greater mean score than the low-ability group through each phase of the study. This is not the case for the text with comic group, where the low-ability group has greater mean scores for achievement. This group also showed the greatest amount of positive change (+.8) from prior knowledge to achievement. Based on this observation the researcher concludes there is no interaction between medium form and learner's abilities on facilitating achievement.

The only significant difference observed in this study was in (6) the interaction between learner's perceived mental effort to learn from a medium and the learners' abilities. This difference is between high- and low-ability groups and the immediate post-test of the self-reported investment of mental effort. The low ability group showed significantly more investment of mental effort

directly after the treatment. However, their perceptions decreased one week later on the delayed post-test which then showed no significant difference when compared to the high-ability group.

It was also observed that there was no significant difference between the influence of a comic strip and the animated section of the video on students' achievement. Therefore, incorporating an animated section of content in a video program does not increase learning retention. (7) The exploration between learners' preconception of mental effort on learner achievement supported Cennamo's (1993) findings that the perceived mental effort investment influences the achievement scores of the students (Tables 4.3, 4.5). The overall findings of this study supported Salomon's (1984) conclusion that preconceptions of a medium influence the amount of mental effort invested.

RECOMMENDATIONS

The following recommendation are suggested to continue the search for strategies in which to design more effective video-based lessons.

1. Examine why learners perceive one medium easier or more difficult than another.

2. Examine learners' preconceptions of media and the ways that preconceptions can be altered.
3. Expand on this study with the fall/spring school year with students who are considered "average" at fifth grade reading level.
4. Compare preconception, mental effort, and achievement of middle students with those of high school students.

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APPENDIX A

INFORMED CONSENT FORM

INFORMED CONSENT FORM
OLD DOMINION UNIVERSITY
AND NASA LANGLEY RESEARCH CENTER

Title of Project: Video Versus Print Material: The Investment of Mental Effort on Learning Through the Different Medium

Investigator: Lisa Coleman
NASA Langley Research Center
Office of Education
M/S 400
Hampton, VA 23681
(804) 864-9496

1. This section provides an explanation of the study in which you will be participating:

   A. The intended research study consists of two phases, a pilot phase and a main phase. The phase of the study in which you will be participating is the main phase.

The purpose of this research is: (1) to compare three treatment groups on learner's perceived mental effort and achievement on a test of recall and inference items. (2) To examine the relationship between learner's perceived mental effort in learning from print and video and learner's abilities. (3) To explore the correlation between learning from print and video with learner's abilities.

   B. If you agree to take part in this research you will be asked to:

   - Take a 13-item multiple choice pretest and posttest.
   - Be assigned to one of three treatment groups.
     Treatment 1- Read a text-based lesson.
     Treatment 2- Read a text-based lesson that includes visualization of some of the text-content, **or,**
     Treatment 3- Watch an instructional video lesson that included an animated segment of the content.

   Participants in this research will also receive free educational materials from NASA.

C. Your participation in this study will take three class meetings about 30 minutes each, for a total time of one and one-half hours of class time. Your name will not be associated with the data in anyway, nor will your test scores be posted. The data (test scores) will be analyzed on a group basis and the results used to improve the instructional design of videos.

D. The risks associated with participation in this study are negligible.

E. If you do not wish to participate in this study, you will not be penalized in any way. Your participation in voluntary.

2. This section describes **your rights as a research participant**.

A. The purpose of the study and your role in it will be explained by the investigator (Lisa Coleman). You may ask any questions about the study procedures, and these questions will be answered. Further questions should be directed to:

Lisa Coleman
NASA Langley Research Center
Office of Education
Hampton, VA 23681
(804) 864-9496

B. Your participation in this research is confidential. Only the person in charge of this research (Lisa Coleman) will have access to your identity and to information that can be associated with your identity. In the event of publication of this research, no personally identifying information will be disclosed.

C. Your participation is voluntary. You are free to stop participating in the study at any time, or to decline to answer any specific questions without penalty.

3. This section indicates that you and your parent (or guardian) are giving your **informed consent to participate** in the study. This consent form **must be returned** to your teacher no later than the day of the study.

Participant:

I agree to participate in a scientific investigation of the mental effort investment on learning through television. I understand that this research is an authorized part of the education and research program of Old Dominion University and NASA Langley Research Center.

I understand the information given to me about the study, and I understand any questions will be answered by the investigator. I understand and agree to the conditions of this study as described.

I understand if I choose not to participate in the study that I will not be penalized in my classwork.

I understand that my participation in this research is voluntary, and that I may withdraw from this study at any time by notifying the person in charge (Lisa Coleman).

I understand that because I am under 18 years of age that I must have a parent/guardian sign the consent form in order to participate in the study.

_____ _____

Student Signature Date

Parent/Guardian:

I have read the contents of this form and understand the information about the study which my child is to participate.

I understand that my child's participation in this study is voluntary, and that my child may withdraw from this study at any time by notifying the investigator.

I understand that the information from this study is considered confidential and only the investigator will have access to the identity of the participants about whom information is obtained. The information obtained will be kept confidential from public scrutiny, from parents and peers, and from legal and school authorities. I understand that data will be collected in a manner that insures anonymity.

To the best of my knowledge and belief, my child has no physical or mental illness or difficulties that would increase the risk to him/her of participation in this study.

This is to certify that I consent to a give permission for my child's participation as a volunteer in this program of investigation.

_____ _____

Parent/Guardian Signature Date

APPENDIX B

PRECONCEPTION AND PRIOR KNOWLEDGE PRE-TEST

Pre-test

DIRECTIONS: There are 13 questions to be answered. Each question is multiple choice. Please read all questions carefully, select the letter (A,B,C,D) which best answers the question and darken the circle which corresponds with the letter you think is correct. This questionnaire should take no longer than 30 minutes, however, you may have whatever time you need to finish.

Directions: Questions 1-8 ask you to think about the level of difficulty in learning different tasks from a video and from printed text. Select the response which most closely matches what you believe to be true for you in learning from these two medium.

1. How difficult would it be for you to learn to solve a math problem from an instructional video lesson?

O A. very easy
O B. easy
O C. difficult
O D. very difficult

2. How difficult would it be for you to learn to solve a math problem from a printed text?

O A. very easy
O B. easy
O C. difficult
O D. very difficult

3. How difficult is it to concentrate on material while watching an instructional video lesson?

O A. very easy
O B. easy
O C. difficult
O D. very difficult

4. How difficult is it to concentrate on the material when reading?

O A. very easy
O B. easy
O C. difficult
O D. very difficult

5. How difficult is it to remember how to play a game after watching the directions on a video?

O A. very easy
O B. easy
O C. difficult
O D. very difficult

6. How difficult is it to member how to play a game after you finished reading the directions?

O A. very easy
O B. easy
O C. difficult
O D. very difficult

7. How difficult is it to recall details after watching an instructional video lesson?

O A. very easy
O B. easy
O C. difficult
O D. very difficult

8. How difficult is it to recall details after you read a lesson?

O A. very easy
O B. easy
O C. difficult
O D. very difficult

Directions: Use the highway map to answer questions 9-13. Use the space on the right side of the page to do you computations for questions 9-13. You may use a calculator.

9. What directions is Boston from Westie.

O A. North (N)
O B. South (S)
O C. East (E)
O D. West (W)

10. What direction is Barker from Westie?

O A. North (N)
O B. South (S)
O C. East (E)
O D. West (W)

11. What is the DISTANCE from Bassett City to Boston using Route 29?

O A. 118 kilometers
O B. 120 kilometers
O C. 238 kilometers
O D. 320 kilometers

12. You are driving from Airdale to Terrier Town, how much TIME will it take to drive 358 kilometers on Route 29 at 85 kilometers per hour?

O A. 2.9 hours or 2 hours and 54 minutes
O B. 3.3 hours or 3 hours and 18 minutes
O C. 4.2 hours or 4 hours and 12 minutes
O D. 5.1 hours or 5 hours and 6 minutes

13. It is 152 kilometers between Route 12 and Roll Over, what SPEED does an airplane need to travel to make it in 1 hour and 30 minutes (1.5)?

O A. 98 kilometers per hour

O B. 101 kilometers per hour

O C. 180 kilometers per hour

O D. 210 kilometers per hour

APPENDIX C

IMMEDIATE AND DELAYED POST-TEST

TEXT GROUP
post-test

DIRECTIONS: There are 8 questions to be answered. Each question is multiple choice. Please read all questions carefully, select the letter (A,B,C,D) which best answers the question and darken the circle which corresponds with the letter you think is correct. This questionnaire should take no longer than 30 minutes, however, you may have whatever time you need to finish.

Directions: Read questions 1-8 carefully. The questions ask you how much or how hard you think it is to learn from a print-text lesson.

1. How hard did you have to concentrate while reading the print-text lesson?

O A. not very hard
O B. not hard
O C. hard
O D. very hard

2. How much did the print-text lesson make you think?

O A. not very hard
O B. not hard
O C. hard
O D. very hard

3. How hard did you try to understand the print-text lesson?

O A. not very hard
O B. not hard
O C. hard
O D. very hard

Directions: Use the highway map to answer questions 4-8. Use the space on the right side of the page to do your computations for questions 6-8. You may use a calculator.

4. What direction is Boston from Westie.

O A. North (N)
O B. South (S)
O C. East (E)
O D. West (W)

5. What direction is Barker from Westie?

O A. North (N)
O B. South (S)
O C. East (E)
O D. West (W)

6. What is the DISTANCE from Bassett City to Boston using Route 12?

O A. 118 kilometers
O B. 120 kilometers
O C. 238 kilometers
O D. 320 kilometers

7. You are driving from Airdale to Terrier Town, how much TIME will it take to drive 358 kilometers on Route 29 at 85 kilometers per hour?

O A. 2.9 hours or 2 hours and 54 minutes
O B. 3.3 hours or 3 hours and 18 minutes
O C. 4.2 hours or 4 hours and 12 minutes
O D. 5.1 hours or 5 hours and 6 minutes

8. It is 152 kilometers between Route 12 and Roll Over, what SPEED does an airplane need to travel to make it in 1 hour and 30 minutes (1.5)?

O A. 98 kilometers per hour

O B. 101 kilometers per hour

O C. 180 kilometers per hour

O D. 210 kilometers per hour

TEXT With VISUAL
post-test

DIRECTIONS: There are 12 questions to be answered. Each question is multiple choice. Please read all questions carefully, select the letter (A,B,C,D) which best answers the question and darken the circle which corresponds with the letter you think is correct. This questionnaire should take no longer than 30 minutes, however, you may have whatever time you need to finish.

Directions: Read questions 1-7 carefully. The questions ask you how much or how hard you think it is to learn from print-text lesson and comic strip.

1. How hard did you have to concentrate while reading the print-text lesson?

O A. not very hard
O B. not hard
O C. hard
O D. very hard

2. How hard did you have to concentrate while reading the comic strip?

O A. not very hard
O B. not hard
O C. hard
O D. very hard

3. How much did the print-text lesson make you think?

O A. not very hard
O B. not hard
O C. hard
O D. very hard

4. How much did the comic strip make you think?

O A. not very hard
O B. not hard
O C. hard
O D. very hard

5. How hard did you try to understand the print-text lesson?

O A. not very hard
O B. not hard
O C. hard
O D. very hard

6. How hard did you try to understand the comic strip?

O A. not very hard
O B. not hard
O C. hard
O D. very hard

7. How much harder was it to learn from the comic strip then from the printed-text?

O A. not very hard
O B. not hard
O C. hard
O D. very hard

Directions: Use the highway map to answer questions 8-12. Use the space on the right side of the page to do your computations for questions 10-12. You may use a calculator.

8. What direction is Boston from Westie.

O A. North (N)
O B. South (S)
O C. East (E)
O D. West (W)

9. What direction is Barker from Westie?

O A. North (N)
O B. South (S)
O C. East (E)
O D. West (W)

10. What is the DISTANCE from Bassett City to Boston using Route 12?

O A. 118 kilometers
O B. 120 kilometers
O C. 238 kilometers
O D. 320 kilometers

11. You are driving from Airdale to Terrier Town, how much TIME will it take to drive 358 kilometers on Route 29 at 85 kilometers per hour?

O A. 2.9 hours or 2 hours and 54 minutes
O B. 3.3 hours or 3 hours and 18 minutes
O C. 4.2 hours or 4 hours and 12 minutes
O D. 5.1 hours or 5 hours and 6 minutes

12. It is 152 kilometers between Route 12 and Roll Over, what SPEED does an airplane need to travel to make it in 1 hour and 30 minutes (1.5)?

O A. 98 kilometers per hour

O B. 101 kilometers per hour

O C. 180 kilometers per hour

O D. 210 kilometers per hour

VIDEO GROUP
post-test

DIRECTIONS: There are 12 questions to be answered. Each question is multiple choice. Please read all questions carefully, select the letter (A,B,C,D) which best answers the question and darken the circle which corresponds with the letter you think is correct. This questionnaire should take no longer than 30 minutes, however, you may have whatever time you need to finish.

Directions: Read questions 1-7 carefully. The questions ask you how much or how hard you think it is to learn from a video lesson.

1. How hard did you have to concentrate while watching the lesson in order to learn from the video?

O A. not very hard
O B. not hard
O C. hard
O D. very hard

2. How hard did you have to concentrate while watching the animated (cartoon) section of the video?

O A. not very hard
O B. not hard
O C. hard
O D. very hard

3. How much did the video lesson make you think?

O A. not very much
O B. not much
O C. much
O D. very much

4. How much did the animated (cartoon) section of the lesson make you think?

O A. not very much
O B. not much
O C. much
O D. very much

5. How hard did you try to understand the video lesson?

O A. not very hard
O B. not hard
O C. hard
O D. very hard

6. How hard did you try to understand the animated (cartoon) section of the video lesson?

O A. not very hard
O B. not hard
O C. hard
O D. very hard

7. How much harder was it to learn from the animated section of the lesson then the rest of the video?

O A. not very hard
O B. not hard
O C. hard
O D. very hard

Directions: Use the highway map to answer questions 8-12. Use the space on the right side of the page to do your computations for questions 10-12. You may use a calculator.

8. What direction is Boston from Westie.

O A. North (N)
O B. South (S)
O C. East (E)
O D. West (W)

9. What direction is Barker from Westie?

O A. North (N)
O B. South (S)
O C. East (E)
O D. West (W)

10. What is the DISTANCE from Bassett City to Boston using Route 12?

O A. 118 kilometers
O B. 120 kilometers
O C. 238 kilometers
O D. 320 kilometers

11. You are driving from Airdale to Terrier Town, how much TIME will it take to drive 358 kilometers on Route 29 at 85 kilometers per hour?

O A. 2.9 hours or 2 hours and 54 minutes
O B. 3.3 hours or 3 hours and 18 minutes
O C. 4.2 hours or 4 hours and 12 minutes
O D. 5.1 hours or 5 hours and 6 minutes

12. It is 152 kilometers between Route 12 and Roll Over, what SPEED does an airplane need to travel to make it in 1 hour and 30 minutes (1.5)?

O A. 98 kilometers per hour

O B. 101 kilometers per hour

O C. 180 kilometers per hour

O D. 210 kilometers per hour

APPENDIX D

PRINT-TEXT AND

PRINT-TEXT WITH VISUAL MATERIAL

THINK BIGG
TEXT

SERIES TITLE: Think BIGG

Navigating: How Do We Get There From Here?

The story takes place in a laboratory - inventor's workshop. A large roughhewn workbench is set in the middle of the workshop.

Positioned on the workbench is a computer. The cover is off and some of its internal wires are exposed. The computer has a sick forlorn expression.

BIGGS approaches the workbench with a large screwdriver and large thermometer. He is worried and in a hurry. He sticks the thermometer in the computer's mouth and proceeds to disconnect something on the computer when he realizes he has company.

BIGGS

Welcome. Pat Biggs at your service. Oh give me second, let me loosen this connection.

(Biggs turns and loosens a cable then turns to the camera as he wipes his hands with a cloth.)

As I said, Patterson Biggs at your service.

Wow! The boss said she was sending in a major intelligence crew to back me up on this mission accomplish.

You look like a real smart bunch to me.

(Biggs sits back in his seat relieved.)

It's a good thing. Cause we have an important mission to accomplish. You see I am a mathematics, scientific ace educator, inventor, pilot who's gone undercover as a clever but simple aircraft mechanic.
That explains why we're hanging out in an airplane hangar.

(Biggs puts his feet up on the bench.)

It's a dirty job but the money's good. There are lots of benefits. I get to take things apart, figure out how they work and even put them back together. I'm a problem solver and inventor. If there's not a problem, I'll invent one.

Oh yeah, I love a great challenge. And girls and boys, do we have a challenge facing us today. You see you are my *accomplishees*.

Accomplishees? No, that's a combination of the words accomplice and employees.

Unfortunately you won't be getting paid. What I meant to say was accomplices on time. No, not in crime, but we do have to get there on time!

(Biggs steps close to the computer, looks into the monitor then pats it trying to comfort it.)

You see my friend here - Giggs . . . that's short for gigabytes because she has lots of them. She is real sick. It seems to have started two or three days ago, when she caught a common computer cold.

(Biggs walks away from the computer.)

I mean she had been coughing and sneezing a little bit, but it was only yesterday when I realized how bad it was. Her screen went green. Everything locked up.

(Biggs paces and his hand gestures get bigger and more expressive. He is worried and guilt-ridden.)

I couldn't get any audio or visual response. It's just not like Giggs. She always has something to say or a new way of looking at things and explaining them. She's one of my best friends. She helps me fix lots of things.

(Biggs points to a corner in the darkness.)

Like that plane. Without Giggs that ship over there may be **grounded** for good and for **sure** my wings will be clipped.

Then this contagion message appeared on Giggs' blue distorted monitor face:

Danger. Danger. This computer has the contagion. A common computer cold will put you and Mission Accomplish out of commission.

YOU *must find a cure or it will rapidly spread to* ***all*** *the computers in the world. In a matter of days they too will be out* ***cold.***

(Biggs moves to the workbench. Standing peering over the workbench, he is stern and serious.)

I was up all night surfing the net and I have isolated the digitized antibody card that is sure to cure Giggs' computer cold.

The antidote is located in the town of Scarsdale. We only have 4 hours to retrieve the antidote before every computer in the country starts coughing and have the sniffles.

Our mission is to retrieve the digital antidote card and to cure Giggs! And save all the computers in the world from the common cold! Now crew to accomplish this mission, here are the four objectives we must complete:

1) **Read** road map icons
2) **Learn** features of aeronautical charts
3) **Perform** algebraic equations
4) **Decide** best mode of transport

(Biggs drags the tool box across the floor and heaves it up on the workbench.)

Now to take on this mission, there are some essential tools that we must have.

And when planning a trip as we are - there are also important factors to consider. These factors can include:

- weather
- geography
- amount of stuff you have to take with you
- number traveling
- cost
- time

For the purpose of our mission to retrieve the digital antidote and cure Giggs of this contagious catastrophe, what is the most important factor?

Time. Right - it's time.

Time is of the essence! We've got to get there fast. That requires speed - so we will need to fly. And what about the tools for this mission? Hmm.....

(Biggs digs into the tool box and pulls out a road map. He shrugs.)

A road map! We won't need this, but I'll keep it out anyway.

(Biggs removes an aeronautical chart, a ruler and shoe string.)

This aeronautical chart - we'll need to chart the course. The ruler - this will measure the distance. And the shoe string's Top Secret. It does a lot more than tie your shoe just wait and see.

(Biggs brings out a calculator and an algebra textbook.)

This algebra book will help us with the math and of course the calculator will speed up our computations. Let me see, am I forgetting anything?

(Biggs digs a little deeper into the tool box.)

AH HA! The compass will help us with direction.
You will also need a writing instrument and a data sheet - some place to put our answers. Now, let's review our list of tools we will need to complete our mission.

- Road map
- Aeronautical chart
- Ruler
- Shoe string
- Calculator
- Algebra book
- Compass
- Writing instrument
- Data sheet (paper)

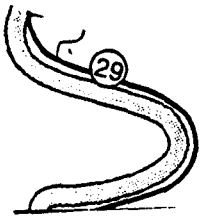
(Biggs is seated at the workbench, he speads out the road map on the workbench.)

Take a look at your map.

(He points to Airdale which is located on the top left corner on road map.)

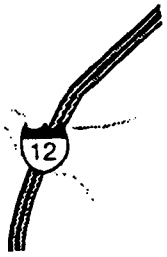
We are here. This is Airdale. It's our departure point.

(Biggs' other hand points out Scarsdale which is located on the lower right hand corner.)



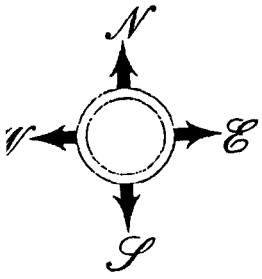
This is Scarsdale, our destination where the digitized antidote is located.

You see the twisting road - Route 29 - it's the only road to get us to Scarsdale from where we are. It is a thin gray line with the numbers inside a circle. That means it's a state road- usually only a 2-laner.



The heavy red line and symbol tells us this is an interstate highway. A multi-lane divided highway. Interstate highways keeps the same route number throughout the states they connect. Interstates are major thoroughfares all across the United States.

(He points to the upper right corner of the road map.)



This is called the compass rose. Every map has to have one as a reference point for NORTH. The large N tells us where North is and from there we can determine South, East and West.
Is Scarsdale north or south of Airdale?

Which way is up? So is Scarsdale north or south of Airdale? The answer is SOUTH.

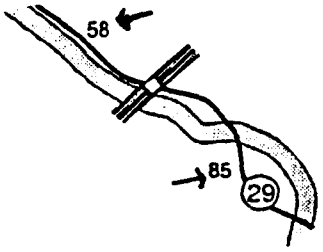
Okay that was good. How many of you had to guess the answer?

This next question is a little tougher. Is Airdale east or west of Scarsdale?

Well, I told you it was going to be a bit harder.

Is Airdale east or west of Scarsdale?
Check the compass rose for the east and west directions then look at Airdale's position on the map. Is it east of Scarsdale?
The answer ... Airdale is WEST of Scarsdale.

With you as accomplices, we'll break the Missions Book of Records, which reminds me we better get tracking. Back to the map. How far is it from Airdale to Scarsdale?



You see the little numbers standing beside the road lines, they are incremental or segmented distances between exits. So if we were to add those all together we could determine exactly how many kilometers it is from Airdale to Scarsdale.

(Biggs picks up the shoe string.)

It's okay for you to try this at home. First we follow the contour of the road with the string.

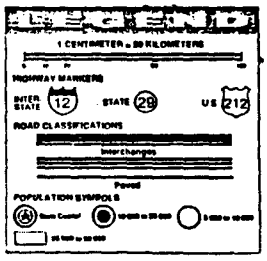
(He lays it on the map along Route 29. The string conforms to the curves of the winding road Route 29.)

Then mark the departure and destination points on the string with your pencil. Now we can measure the string with a ruler.

(Biggs lifts the string from the map and shows thelength of the marked string.)

Now how far is this distance really?

(Biggs points to the lower right corner of the road map.)



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The string is 21 centimeters long.
The map scale shows that 1 centimeter is equal to 20 kilometers. And on the map from Airdale to Scarsdale it is 21 centimeters.

So what we have is
21 centimeters X 20 = ?? kilometers

21 centimeters X 20 kilometers equals 420 kilometers or 262 miles.

(Biggs stands at workbench and smoothes the wrinkles out of the aeronautical chart.)

It's 420 kilometers by car from Airdale to Scarsdale. Did you know that pilots of airplanes and captains of ships use charts when they navigate? That's because they can chart or plot a straight line course between a departure point and a destination point. Now let's look at the aeronautical chart.

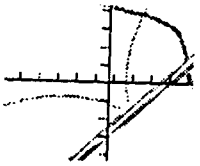
(He points to Airdale, located at the top left corner on the aeronautical chart.)

We are here. This is Airdale - our departure point.

(Then he points to the lower right hand corner of the chart.)

This is Scarsdale, our destination where the digitized antidote is located.

(With a pencil, Biggs points to the hatched marked lines on the chart.)



These are the lines of longitude and latitude. This is navigational information. Longitude and latitude are used to describe our position on the earth.

(Biggs points to the mountains on the chart.)

You see this? It's the Rover Mountain Range. Now I know where the mountains are.

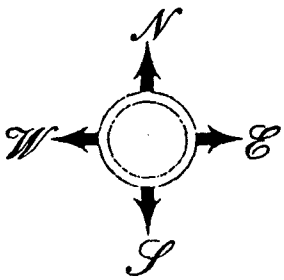
Why do you suppose it's important for a pilot to know where mountains are located?

Knowing where mountains are located helps pilots to insure we have safe flights. Railroad tracks are denoted on aeronautical charts because pilots sometimes follow them from town to town. And it's the same way with rivers.

Could we follow the river from Airdale to Scarsdale? . . . Yes, we could, but the river twists and winds through the Rover Mountains. We'd probably be better off following the mountain range as a visual navigation key.

(He points to the upper right corner of the aeronautical chart.)

This is the compass rose on an aeronautical chart.



It's similar to the compass rose on a highway map and tells us the same information or directional orientation of the chart. See North - South - East - and West.

Remember, earlier we learned by looking at the map that Scarsdale was - in what direction from Airdale?

Look at the chart now and check the compass rose. Is Scarsdale east or west of Airdale?

The answer my accomplice crew is . . EAST.

And from looking at this chart and the road map, we know that Scarsdale is - - - - - SOUTH of Airdale.

(Biggs puts the ruler down on the chart and lines the ruler up with the points for Airdale and Scarsdale.)

So if we are charting the course for my FMT-112 jet from Airdale, our departure point, to our destination, Scarsdale; can you tell me exactly what direction we will be flying?

The answer is... SOUTHEAST

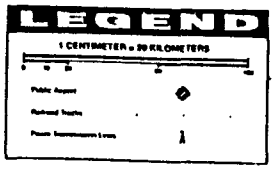
(He uses the ruler as a straight edge to draw a line from the departure point to the destination.)

The shortest distance between two points is a straight line. The airplane can travel in a straight line and the car can't.

Well you saw it - that crooked road Route 29 that we would have to take if we drove to Scarsdale. I knew it all along. The <u>fastest</u> way is by plane!

But for the sake of the nay saying doubters, I will prove my assumption correct!

(Biggs measures the line between Airdale and Scarsdale with the ruler. He checks the scale on the chart and concludes.)



The aeronautical chart scale says 1 centimeter equals 20 kilometers. The straight line

distance from Airdale to Scarsdale is 17 centimeters

One centimeter is equal to 20 kilometers on the chart. And the measurement from Airdale to Scarsdale is 17 centimeters

17 centimeters X 20 kilometers = ?? kilometers

17 centimeters x 20 kilometers = 340 straight line kilometers by air. The airplane *is* faster and it's closer!!

You see, by air the distance is 340 kilometers. By the roadway the distance is 420 kilometers.

(Biggs jumps up from workbench and runs to grab his hat and coat.)

Come on. Our solution is to take to the airways to retrieve the digital antidote. Hurry up, we've got a plane to catch!

(The sick computer, Giggs, groans and tries to talk, but its speech is very slurred.)

GIGGS

Wait. There is more informa . . . tion.

(Different colors and distorted images flicker and roll on the computer monitor. Then on the computer's screen there appears ... MISSION MAN ... appearing from the city's underground out of a manhole.)

MISSION MAN

Hello, gang. Just got off the subway. The city's underground transport. What a way to travel... I love travel. There are so many ways to get from point A to point B.

To determine how much time it will take to travel a certain distance, we have to use this mathematical equation.

Speed equals distance divided by time. . . Or here's another way to look at the equation.

S = D / T

You see SPEED equals DISTANCE divided by TIME.

That means speed is equal to the distance traveled divided by the time it takes to go the distance.

An equation is like a recipe. It is a set of coded letters and symbols. Here's what this formula tells us.

This simple equation will show you how fast, how far, and when you can expect to get where you are going.

It's a good thing to know when you want to go the distance. Get up to speed or arrive on time. It's that simple.

Did you know that it took the astronauts of Apollo 11 about ten hours to travel from earth to the moon. Now that is not including additional earth and moon orbiting time but actual trajectory travel time was 10 hours. The DISTANCE from the earth to the moon is 400,000 kilometers. So if speed equals distance divided by time, how fast was their space ship traveling?

SPEED = DISTANCE / TIME

400,000 kilometers / 10 hours = ?? kilometers

So the Apollo 11 was traveling at 40,000 kilometers per hour or approximately 25,000 miles per hour! Impressive Yes?

(The Mission Man image disappears from the computer's monitor. Biggs fumbles searching for the computer's mouse trying to regain the image. He continues looking at the sick computer.)

BIGGS

Well that's great. Just great. Speed equals distance divided by time. I get it. It's some kind of clue. Right?

It would seem that we aren't suppose to take off for Scarsdale just yet. Obviously, there's more to this problem then we first thought.

How in the world am I suppose to save my good friend, here, from a fate worse than a power surge? How can I cure the contagious computer cold if I can't figure out a clue like S = D/T?

You, my accomplice crew have got to help! If we stick together we can figure this out, but I need your help. It has something to do with that formula. Without Giggs here . . . I'm brainless. I mean clueless. What do you think our mission to Scarsdale has to do with that math formula?

Okay, what I need is a couple of volunteers to help me figure this out right now.

(Suddenly, as if by magic, two students appear and come into the hangar and stand in front of Biggs' workbench.)

AMORY

I'm Amory Cervarich.

KAITLIN

Hi. I'm Kaitlin Bowles.

BIGGS

Thank goodness help has arrived. We have work to do and no time to spare. What do you think the math formula has to do with us getting the antidote in Scarsdale and getting back here in time to save Giggs from this contagious catastrophe?

AMORY

Biggs, you said it yourself. Time is the most important factor, but maybe, just maybe traveling by airplane isn't our best choice. We need to confirm our assumptions. The equation can help. What if we use this equation to figure out the length of time it will take to get to Scarsdale by car and plane?

BIGGS

That's silly. The formula says speed equals distance divided by time. It doesn't tell us how to figure TIME. It tells us how to figure SPEED. Besides I already know the plane will get us there faster.

KAITLIN

Biggs that's the cool thing about an algebra equation like this. If you know the values for 2 of the equation factors you can figure out the third unknown, like with S=D/T.

We can figure the speed an object is traveling if we can find the distance it traveled and the amount of time it took the object to travel that distance. SPEED equals DISTANCE divided by TIME.

AMORY

Likewise, if we know the time it took to travel a certain distance and the speed with which the object was moving, we can determine the distance traveled. The equation then looks like this: **D = T x S**

See. DISTANCE equals TIME multiplied by SPEED. So knowing the time it took to travel a certain distance and the speed which we were traveling allows us to determine the distance we have traveled.

KAITLIN

And if we want to solve the equation for TIME, the formula looks like this: **T = D/ S**
Which means in order to find out how long it will take to travel somewhere, you need to know the DISTANCE and the SPEED that your will be traveling. So, TIME equals DISTANCE divided by SPEED.

Biggs, you already know the distance to Scarsdale from Airdale by car is 420 kilometers.

BIGGS
Yes, and I also know the distance by plane is 324 kilometers and we need to get going because time is ticking away.

AMORY
This won't take very long.
Biggs, what was the distance from Airdale to Scarsdale using Route 29?

BIGGS
Four hundred and twenty kilometers.

KAITLIN
How fast can a car travel on Route 29?

BIGGS
55 miles per hour or 85 kilometers per hour.

KAITLIN
If time equals distance divided by speed like this equation says, let's try it.

(Using a calculator, Amory punches in the numbers given to her by Kaitlin.)

Distance equals 420 kilometers divided by 85 kilometers per hour. So the answer is???

420 kilometers / 85 kilometers per hour = ?? hours

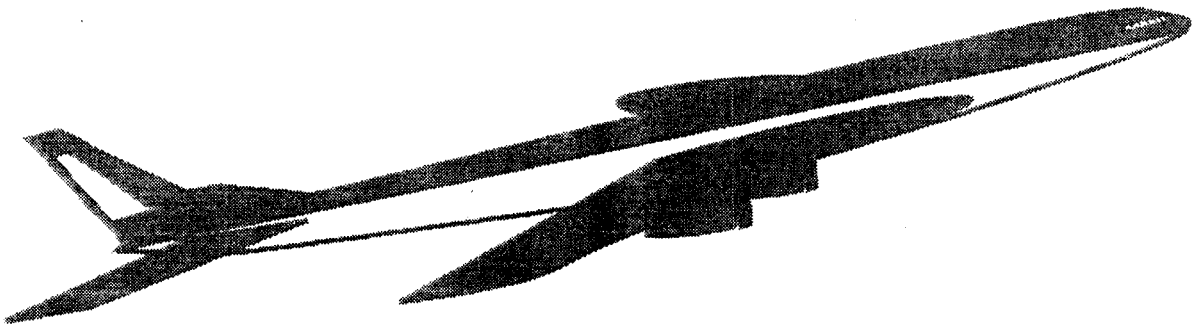
4.9 hours or 4 hours and 54 minutes!

BIGGS
It will take almost 10 hours to DRIVE to Scarsdale and back to the hangar, by then Giggs will be out cold.

The dreaded computer cold will have spread to all the world's computers. So we have to get there faster - my plane, the FMT-112 can do that for us. See, I told you all along - planes are the way to TRAVEL.

AMORY
Not so fast, we better do the math.

THINK BIGG
TEXT WITH COMIC



SERIES TITLE: Think BIGG

Navigating: How Do We Get There From Here?

The story takes place in a laboratory - inventor's workshop. A large roughhewn workbench is set in the middle of the workshop.

Positioned on the workbench is a computer. The cover is off and some of its internal wires are exposed. The computer has a sick forlorn expression.

BIGGS approaches the workbench with a large screwdriver and large thermometer. He is worried and in a hurry. He sticks the thermometer in the computer's mouth and proceeds to disconnect something on the computer when he realizes he has company.

BIGGS

Welcome. Pat Biggs at your service. Oh give me second, let me loosen this connection.

(Biggs turns and loosens a cable then turns to the camera as he wipes his hands with a cloth.)

As I said, Patterson Biggs at your service.

Wow! The boss said she was sending in a major intelligence crew to back me up on this mission accomplish.

You look like a real smart bunch to me.

(Biggs sits back in his seat relieved.)

It's a good thing. Cause we have an important mission to accomplish. You see I am a mathematics, scientific ace educator, inventor, pilot who's gone undercover as a clever but simple aircraft mechanic.
That explains why we're hanging out in an airplane hangar.

(Biggs puts his feet up on the bench.)

It's a dirty job but the money's good. There are lots of benefits. I get to take things apart, figure out how they work and even put them back together. I'm a problem solver and inventor. If there's not a problem, I'll invent one.

Oh yeah, I love a great challenge. And girls and boys, do we have a challenge facing us today. You see you are my *accomplishees*.

Accomplishees? No, that's a combination of the words accomplice and employees.

Unfortunately you won't be getting paid. What I meant to say was accomplices on time. No, not in crime, but we do have to get there on time!

(Biggs steps close to the computer, looks into the monitor then pats it trying to comfort it.)

You see my friend here - Giggs . . . that's short for gigabytes because she has lots of them. She is real sick. It seems to have started two or three days ago, when she caught a common computer cold.

(Biggs walks away from the computer.)

I mean she had been coughing and sneezing a little bit, but it was only yesterday when I realized how bad it was. Her screen went green. Everything locked up.

(Biggs paces and his hand gestures get bigger and more expressive. He is worried and guilt-ridden.)

I couldn't get any audio or visual response. It's just not like Giggs. She always has something to say or a new way of looking at things and explaining them. She's one of my best friends. She helps me fix lots of things.

(Biggs points to a corner in the darkness.)

Like that plane. Without Giggs that ship over there may be **grounded** for good and for **sure** my wings will be clipped.

Then this contagion message appeared on Giggs' blue distorted monitor face:

Danger. Danger. This computer has the contagion. A common computer cold will put you and Mission Accomplish out of commission.

YOU** must find a cure or it will rapidly spread to **all** the computers in the world. In a matter of days they too will be out **cold.

(Biggs moves to the workbench. Standing peering over the workbench, he is stern and serious.)

I was up all night surfing the net and I have isolated the digitized antibody card that is sure to cure Giggs' computer cold.

The antidote is located in the town of Scarsdale. We only have 4 hours to retrieve the antidote before every computer in the country starts coughing and have the sniffles.

Our mission is to retrieve the digital antidote card and to cure Giggs! And save all the computers in the world from the common cold! Now crew to accomplish this mission, here are the four objectives we must complete:

1) **Read** road map icons
2) **Learn** features of aeronautical charts
3) **Perform** algebraic equations
4) **Decide** best mode of transport

(Biggs drags the tool box across the floor and heaves it up on the workbench.)

Now to take on this mission, there are some essential tools that we must have.

And when planning a trip as we are - there are also important factors to consider. These factors can include:

- weather
- geography
- amount of stuff you have to take with you
- number traveling
- cost
- time

For the purpose of our mission to retrieve the digital antidote and cure Giggs of this contagious catastrophe, what is the most important factor?

Time. Right - it's time.

Time is of the essence! We've got to get there fast. That requires speed - so we will need to fly. And what about the tools for this mission? Hmm.....

(Biggs digs into the tool box and pulls out a road map. He shrugs.)

A road map! We won't need this, but I'll keep it out anyway.

(Biggs removes an aeronautical chart, a ruler and shoe string.)

This aeronautical chart - we'll need to chart the course. The ruler - this will measure the distance. And the shoe string's Top Secret. It does a lot more than tie your shoe just wait and see.

(Biggs brings out a calculator and an algebra textbook.)

This algebra book will help us with the math and of course the calculator will speed up our computations. Let me see, am I forgetting anything?

(Biggs digs a little deeper into the tool box.)

AH HA! The compass will help us with direction.
You will also need a writing instrument and a data sheet - some place to put our answers.
Now, let's review our list of tools we will need to complete our mission.

- Road map
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(Biggs is seated at the workbench, he speads out the road map on the workbench.)

Take a look at your map.

(He points to Airdale which is located on the top left corner on road map.)

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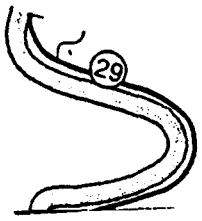

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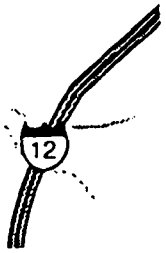

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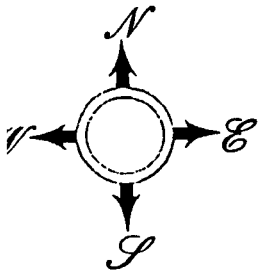

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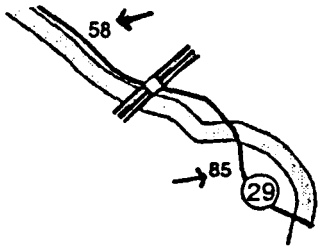

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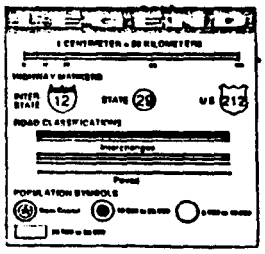
(He lays it on the map along Route 29. The string conforms to the curves of the winding road Route 29.)

Then mark the departure and destination points on the string with your pencil. Now we can measure the string with a ruler.

(Biggs lifts the string from the map and shows thelength of the marked string.)

Now how far is this distance really?

(Biggs points to the lower right corner of the road map.)



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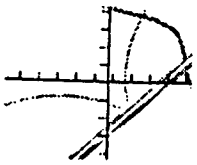
(He points to Airdale, located at the top left corner on the aeronautical chart.)

We are here. This is Airdale - our departure point.

(Then he points to the lower right hand corner of the chart.)

This is Scarsdale, our destination where the digitized antidote is located.

(With a pencil, Biggs points to the hatched marked lines on the chart.)



These are the lines of longitude and latitude. This is navigational information. Longitude and latitude are used to describe our position on the earth.

(Biggs points to the mountains on the chart.)

You see this? It's the Rover Mountain Range. Now I know where the mountains are.

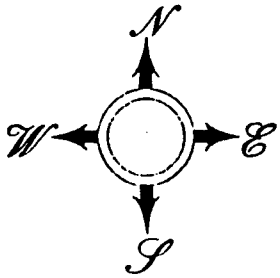
Why do you suppose it's important for a pilot to know where mountains are located?

Knowing where mountains are located helps pilots to insure we have safe flights. Railroad tracks are denoted on aeronautical charts because pilots sometimes follow them from town to town. And it's the same way with rivers.

Could we follow the river from Airdale to Scarsdale? . . . Yes, we could, but the river twists and winds through the Rover Mountains. We'd probably be better off following the mountain range as a visual navigation key.

(He points to the upper right corner of the aeronautical chart.)

This is the compass rose on an aeronautical chart.



It's similar to the compass rose on a highway map and tells us the same information or directional orientation of the chart. See North - South - East - and West.

Remember, earlier we learned by looking at the map that Scarsdale was - in what direction from Airdale?

Look at the chart now and check the compass rose. Is Scarsdale east or west of Airdale?

The answer my accomplice crew is . . EAST.

And from looking at this chart and the road map, we know that Scarsdale is - - - - - SOUTH of Airdale.

(Biggs puts the ruler down on the chart and lines the ruler up with the points for Airdale and Scarsdale.)

So if we are charting the course for my FMT-112 jet from Airdale, our departure point, to our destination, Scarsdale; can you tell me exactly what direction we will be flying?

The answer is... SOUTHEAST

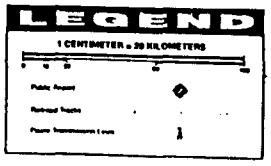
(He uses the ruler as a straight edge to draw a line from the departure point to the destination.)

The shortest distance between two points is a straight line. The airplane can travel in a straight line and the car can't.

Well you saw it - that crooked road Route 29 that we would have to take if we drove to Scarsdale. I knew it all along. The <u>fastest</u> way is by plane!

But for the sake of the nay saying doubters, I will prove my assumption correct!

(Biggs measures the line between Airdale and Scarsdale with the ruler. He checks the scale on the chart and concludes.)



The aeronautical chart scale says 1 centimeter equals 20 kilometers. The straight line

distance from Airdale to Scarsdale is 17 centimeters

One centimeter is equal to 20 kilometers on the chart. And the measurement from Airdale to Scarsdale is 17 centimeters

17 centimeters X 20 kilometers = ?? kilometers

17 centimeters x 20 kilometers = 340 straight line kilometers by air. The airplane *is* faster and it's closer!!

You see, by air the distance is 340 kilometers. By the roadway the distance is 420 kilometers.

(Biggs jumps up from workbench and runs to grab his hat and coat.)

Come on. Our solution is to take to the airways to retrieve the digital antidote. Hurry up, we've got a plane to catch!

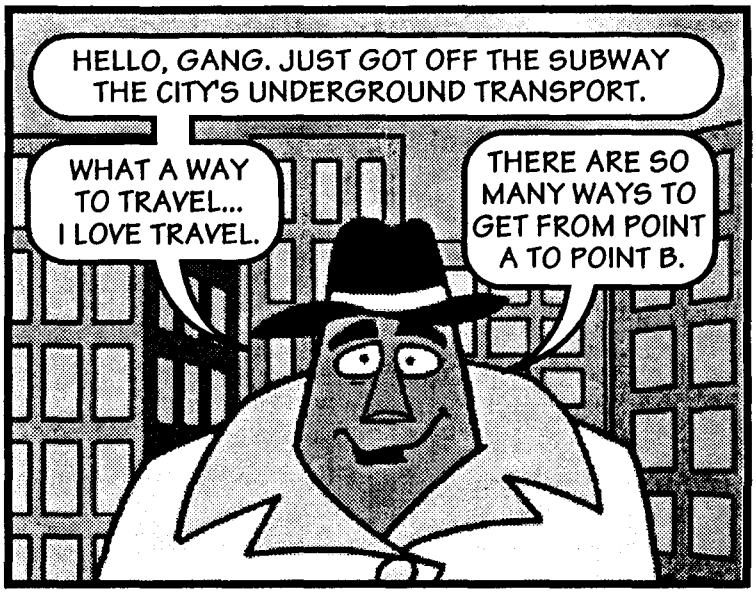
(The sick computer, Giggs, groans and tries to talk, but its speech is very slurred.)

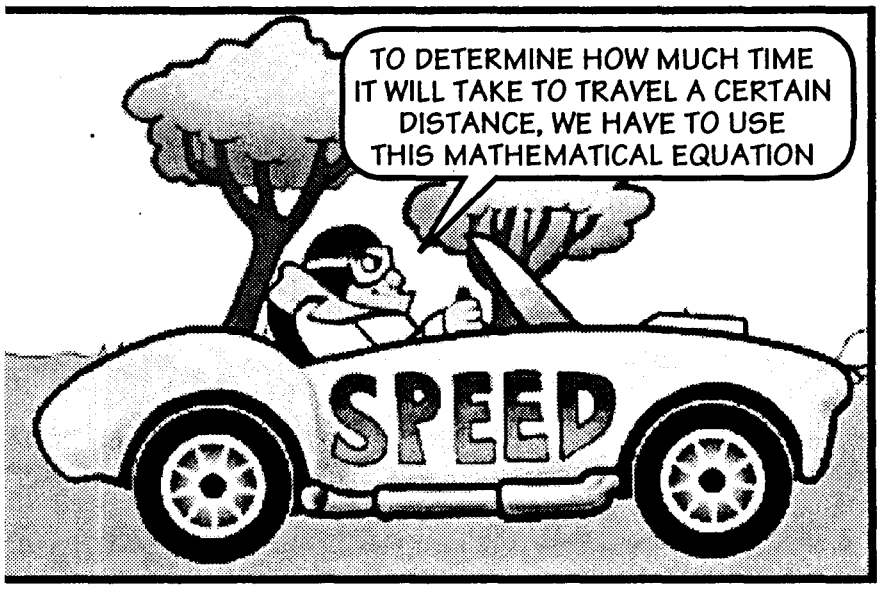
GIGGS

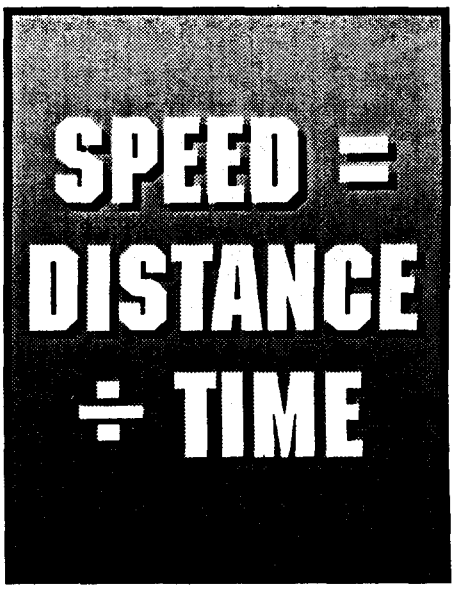
Wait. There is more informa . . . tion.

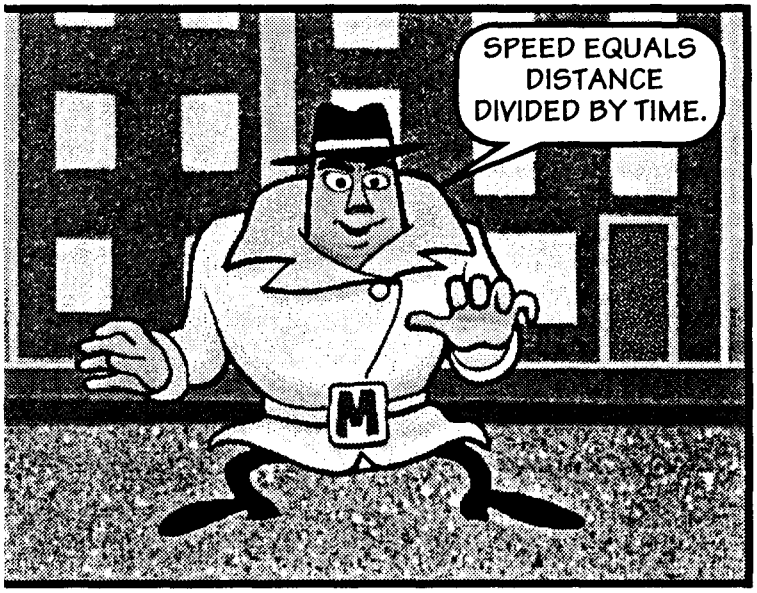
(Different colors and distorted images flicker and roll on the computer monitor. Then on the computer's screen there appears ... MISSION MAN ... appearing from the city's underground out of a manhole.)

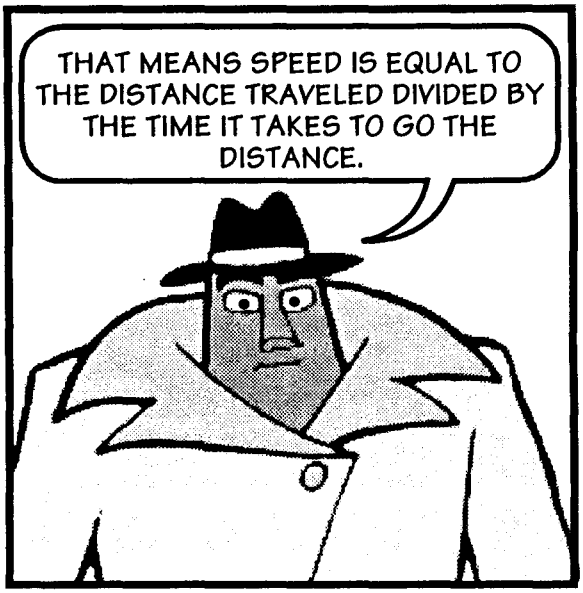

MISSION MAN
M

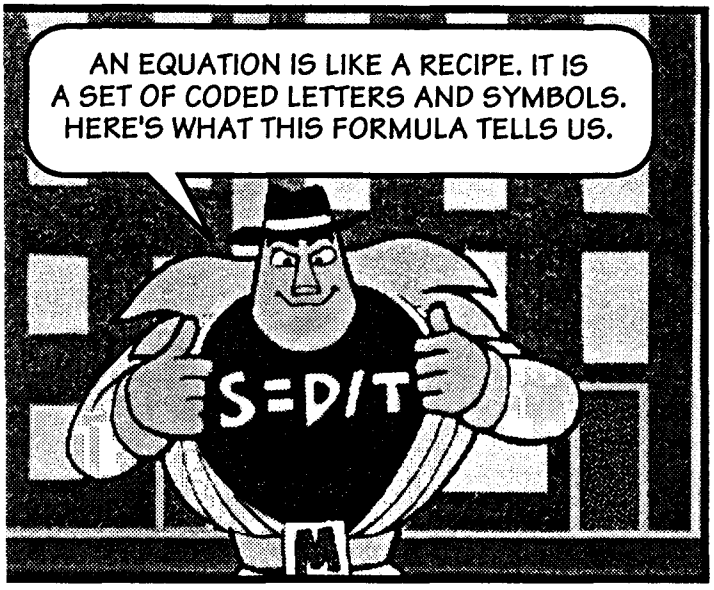

HELLO, GANG. JUST GOT OFF THE SUBWAY THE CITY'S UNDERGROUND TRANSPORT.
WHAT A WAY TO TRAVEL... I LOVE TRAVEL.
THERE ARE SO MANY WAYS TO GET FROM POINT A TO POINT B.

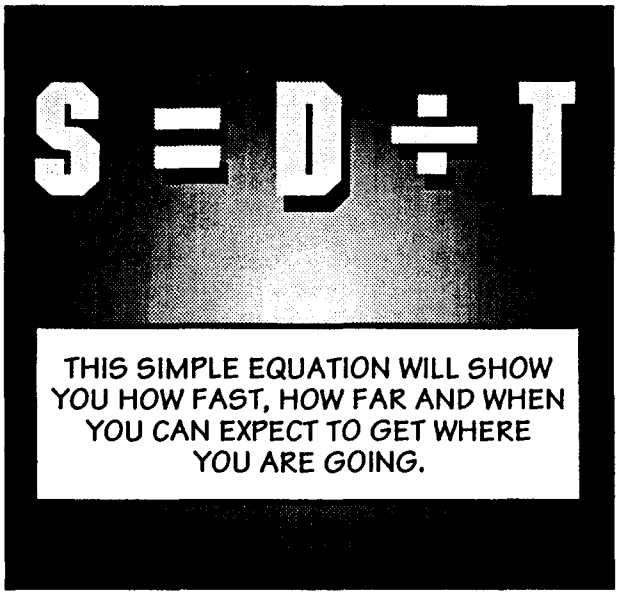

TO DETERMINE HOW MUCH TIME IT WILL TAKE TO TRAVEL A CERTAIN DISTANCE, WE HAVE TO USE THIS MATHEMATICAL EQUATION
SPEED


SPEED =
DISTANCE
÷ TIME

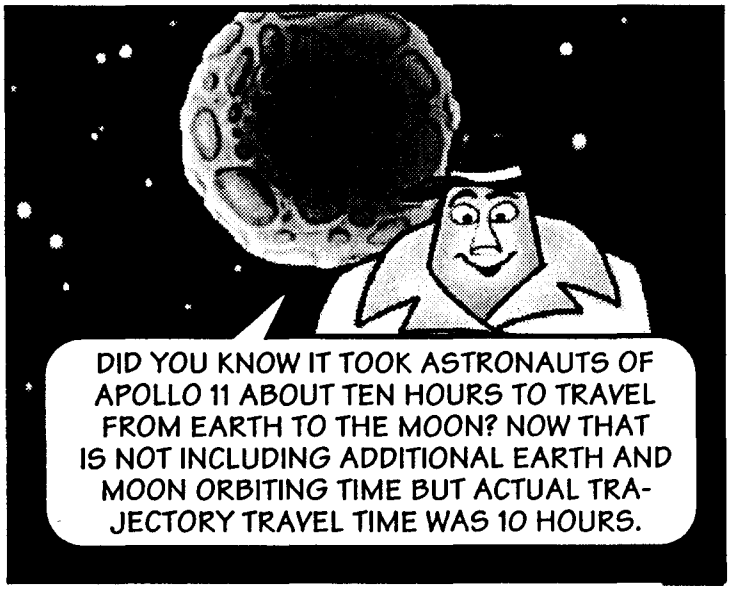

SPEED EQUALS DISTANCE DIVIDED BY TIME.
M

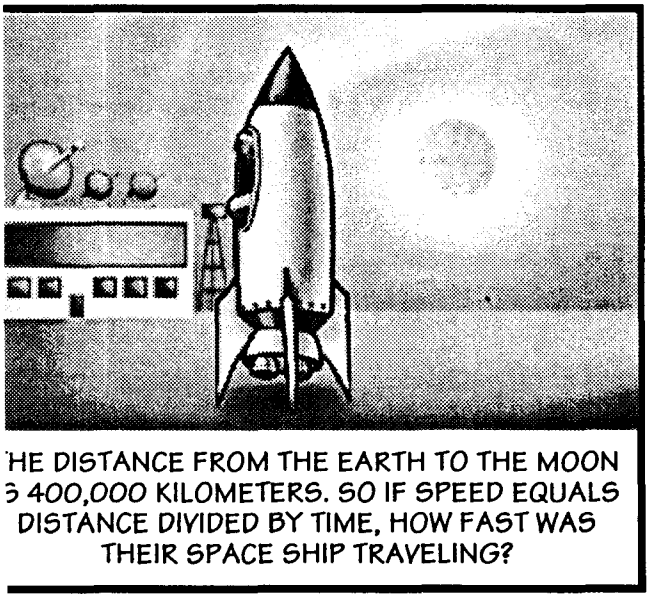

THAT MEANS SPEED IS EQUAL TO THE DISTANCE TRAVELED DIVIDED BY THE TIME IT TAKES TO GO THE DISTANCE.

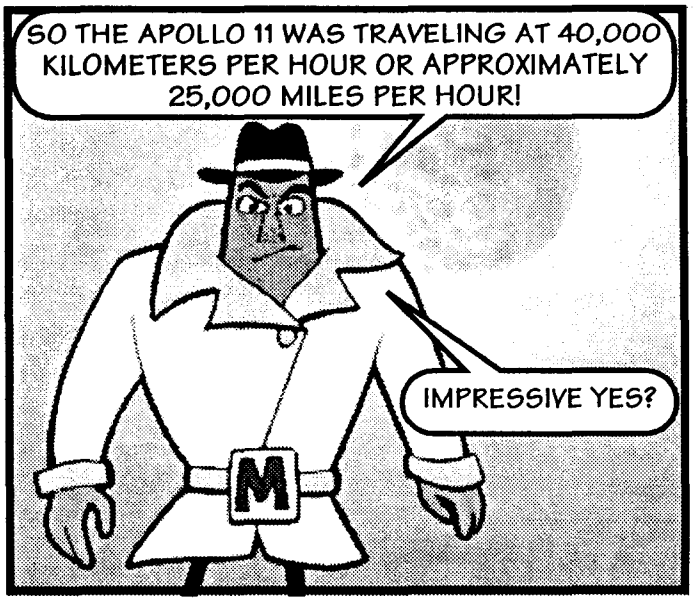

AN EQUATION IS LIKE A RECIPE. IT IS A SET OF CODED LETTERS AND SYMBOLS. HERE'S WHAT THIS FORMULA TELLS US.
S=D/T
M


S=D÷T
THIS SIMPLE EQUATION WILL SHOW YOU HOW FAST, HOW FAR AND WHEN YOU CAN EXPECT TO GET WHERE YOU ARE GOING.


IT'S A GOOD THING TO KNOW WHEN YOU WANT TO GO THE DISTANCE. GET UP TO SPEED OR ARRIVE ON TIME. IT'S THAT SIMPLE.
CLOSED
M


DID YOU KNOW IT TOOK ASTRONAUTS OF APOLLO 11 ABOUT TEN HOURS TO TRAVEL FROM EARTH TO THE MOON? NOW THAT IS NOT INCLUDING ADDITIONAL EARTH AND MOON ORBITING TIME BUT ACTUAL TRAJECTORY TRAVEL TIME WAS 10 HOURS.


HE DISTANCE FROM THE EARTH TO THE MOON 3 400,000 KILOMETERS. SO IF SPEED EQUALS DISTANCE DIVIDED BY TIME, HOW FAST WAS THEIR SPACE SHIP TRAVELING?


SO THE APOLLO 11 WAS TRAVELING AT 40,000 KILOMETERS PER HOUR OR APPROXIMATELY 25,000 MILES PER HOUR!
IMPRESSIVE YES?
M

(The Mission Man image disappears from the computer's monitor. Biggs fumbles searching for the computer's mouse trying to regain the image. He continues looking at the sick computer.)

BIGGS

Well that's great. Just great. Speed equals distance divided by time. I get it. It's some kind of clue. Right?

It would seem that we aren't suppose to take off for Scarsdale just yet. Obviously, there's more to this problem then we first thought.

How in the world am I suppose to save my good friend, here, from a fate worse than a power surge? How can I cure the contagious computer cold if I can't figure out a clue like S = D/T?

You, my accomplice crew have got to help! If we stick together we can figure this out, but I need your help. It has something to do with that formula. Without Giggs here . . . I'm brainless. I mean clueless. What do you think our mission to Scarsdale has to do with that math formula?

Okay, what I need is a couple of volunteers to help me figure this out right now.

(Suddenly, as if by magic, two students appear and come into the hangar and stand in front of Biggs' workbench.)

AMORY

I'm Amory Cervarich.

KAITLIN

Hi. I'm Kaitlin Bowles.

BIGGS

Thank goodness help has arrived. We have work to do and no time to spare. What do you think the math formula has to do with us getting the antidote in Scarsdale and getting back here in time to save Giggs from this contagious catastrophe?

AMORY