This is to certify that the

dissertation entitled

THE EFFECTS OF INTERACTIVE MULTIMEDIA
IN GEOGRAPHIC EDUCATION FOR DYSLEXIC STUDENTS

presented by

Alison E. Philpotts

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Geography

Major professor

Date 5/10/01

THE EFFECTS OF INTERACTIVE MULTIMEDIA IN GEOGRAPHIC EDUCATION FOR DYSLEXIC STUDENTS

By

Alison E. Philpotts

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Department of Geography

2001

ABSTRACT

THE EFFECTS OF INTERACTIVE MULTIMEDIA IN GEOGRAPHIC EDUCATION FOR DYSLEXIC STUDENTS

By

Alison E. Philpotts

To evaluate the effectiveness of interactive multimedia as a teaching device to help dyslexic students and to narrow the learning gap between dyslexic and non-dyslexic students, an eighth-grade geography lesson was created in both a traditional-text and interactive-multimedia format. The content was guided by the National Geography Standards and focused on Michigan's coastal dunes. The lesson was divided into four sections, and half of each group of students (dyslexic, non-dyslexic) saw a traditional, multimedia, traditional, multimedia sequence and the other half multimedia, traditional, multimedia, traditional. The accuracy and response times of subjects were recorded. Attitude questions aimed at measuring level of enthusiasm were also asked. Test design enabled comparison of the performance and attitudes between dyslexic vs. non-dyslexic students and between traditional vs. multimedia format.

A total of forty-six eighth grade students participated in the testing. They first answered pretest questions and then proceeded through the four sections of the lesson. At the end of each section, they answered multiple-choice content questions. At the end of all four sections, the students answered on-screen attitude questions and were asked open-ended questions.

Accuracy improved significantly between the pretest and the four section posttests. A logit analysis showed that both dyslexic and non-dyslexic students answered more questions accurately with the multimedia format, and they learned more when the same information was presented to them in a combination of different ways (text, graphics and sound, for example). They were also more likely to answer correctly if they had seen the same question on the pretest. Statistically, dyslexics improved significantly more than non-dyslexics when using multimedia, but the difference was very small. The higher level of correct answers for the entire set of subjects did mean, however, that the accuracy ratio between non-dyslexics and dyslexics decreased with multimedia (odds ratio of 1.07 vs. 1.15; full closing of the gap would have resulted in an odds ratio of 1.00). An analysis of variance on reaction times showed that multimedia and the increased number of ways the same information was presented were associated with improved (decreased) response time for both groups; dyslexics improved more with multimedia; and both groups did better with multimedia, especially when the question had not appeared on the pretest. Answers to attitude questions indicated overwhelmingly that students in both groups were more enthusiastic about the multimedia materials than the traditional text.

Although the decrease in the gap between the two groups was limited, the message is clear that multimedia can be a very effective tool for teaching geography to all students, whether they are dyslexic or non-dyslexic.

ACKNOWLEDGMENTS

Many professors, friends, colleagues, and family have helped me develop, implement, support, and produce this dissertation. To them I owe an overwhelming debt of gratitude. First, I would like to thank my doctoral committee, particularly my advisor Dr. Judy M. Olson, who spent many long days and nights providing endless guidance. To Dr. Richard Groop who provided me with excellent opportunities through teaching, research, and map production, and did so with a friendly smile. Dr. Gary Manson and Dr. Alan Arbogast provided scholarly growth and intellectual stimulation that aided in the content and methodological development of this dissertation. Second, I must thank Dr. René Hinojosa and Dr. Randy Schaetzl for providing me with assistantships and fellowships that were financially invaluable.

Third, my peers and colleagues have constantly encouraged and provided feedback for developing and carrying through this research. Particularly, Jessica Dolanski and Amy Lobben were there from the beginning. Mr. and Mrs. Dolanski welcomed me into their home, not to mention Mrs. Dolanski was incredibly helpful with linking me with dyslexic students. My colleagues in my new home, Shippensburg University, are more than supportive and encouraging, and have helped me to finish.

Finally, I must thank my family. My parents and sisters who have always been a source of inspiration, an amazing Grandmother who is always striving to learn more, and a set of adorable nephews and nieces who remind me to enjoy life. And last, there is Dr. Thomas P. Feeney, who will soon be family. He has my heart and provides no alternative than to finish.

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CHAPTER 1: INTRODUCTION

Technology, Society, Maps and Dyslexia

Mapmaking constantly adapts to both technological and social changes. With the transition into the new millennium, we find digital products infiltrating all aspects of life. In residential homes to cyber cafes to school classrooms, the personal computer has become commonplace, and such multimedia devices as sound cards, scanners, CD-ROMs, DVDs, and digital cameras are gaining in popularity. "Web" and "Internet" have become household terms, and one can locate information on virtually any topic by "surfing the net." Mapmaking, like so many other endeavors at this stage in history, has come to depend on digital technology, and it is increasingly common to find new map products in a multimedia milieu or on the Internet.

Technology, in itself, is a social change as well as an engineering feat. Other social changes, including commonly held beliefs and viewpoints, are affecting cartography as well. In the last several decades, there has been a more compassionate approach to understanding and accommodating populations with disabilities. Geographers have begun to react to this social change and, as chapter 2 will show, a few isolated studies have focused on geography for, and by, disabled people. In cartography, we find the notion of the "average map reader" to have lost its emphasis not just because the psychology of maps has lost some of its centrality in cartographic research but because cartographers are part of this social trend toward accommodation, a notion antithetical to that of "average map reader" or "best map for the majority of people."

The topical roots for this dissertation research come from living with and embracing these changes in technology and society. Combining the requirement of a dissertation with a lifetime passion for geography, maps, and art, this project started out as a vague notion about looking at the presence of multimedia in geography and assessing the effectiveness of multimedia in teaching. Many young scholars have been attempting to assess the same general phenomenon. One must look no further than the papers given at a national geography meeting or at the titles of graduate theses and dissertations to find the evidence. The numbers of studies suggest that the topic indeed has currency; on the other hand, they suggest that such studies may become as endless as the investigations of circle sizes and gray tones in the 1960s and 1970s.

Another event influenced the choice of topic, however. While engaged in identifying and investigating the theoretical and philosophical underpinnings of cartography during my doctoral studies, I found myself winding down varying paths and delving into a variety of geographic literature. Surviving lessons on radical geography and post-modern thought, my essentially positivist attitude caused my attention to focus on the emerging literature on geography for and by disabled populations. It is the interesting dynamic between multimedia and maps for disabled populations that separates this dissertation from other studies of geographic multimedia.

Wonderful opportunities arose with the Grand Traverse Dyslexia Association where I observed tutors using multisensory techniques and accommodating different cognitive learning styles to help students with learning disabilities. Two things became apparent. First, the students with learning disabilities often complained about how difficult and boring they found geography (a disheartening blow to someone so passionate about the subject). Second, for other subjects that students generally found difficult, there were technical aids such as audiotapes (for reading and phonics) and interactive computer programs (for math). It was noticeable that there were no technical devices or software in use to support students with dyslexia in learning geography.

This absence of geography-oriented technical support for students with learning disabilities clinched my resolve to look into multimedia for dyslexics. Computers and maps are important tools in geography. The recent flood of computers and the dispersion of their use allow geographers and cartographers to create, relatively easily and cheaply, products specifically targeted to help particular populations. My underlying general hypothesis, of course, was that multimedia would be helpful to the dyslexic population attempting to learn geography. The challenge was to see if the hypothesis was correct.

The Research Objective and General Expectations

The objective of this study, then, was to assess the usefulness of interactive multimedia in teaching geography to dyslexic students. Since dyslexia is a learning disorder that limits people's ability to process written language, and since dyslexic learning strategies include multisensory techniques to stimulate multiple or alternative pathways to the brain, it seemed reasonable to ask whether presenting geographic information in the combination of different formats made possible by multimedia might be helpful for dyslexics.

The experiment involved a geography lesson that was developed in two formats: traditional text and interactive multimedia. Both formats relied heavily on graphic information such as maps, graphs, and diagrams. In the two formats, students encountered information in a variety of presentation types, including static maps, animation, text, and sound. They could also encounter combinations of presentation types. For example, in the text format a static map could be accompanied by a description in written text. In the multimedia format, a map might be animated, with sound supplementing the written description. Presentation types were identified and cataloged to evaluate learning differences between dyslexic and non-dyslexic students.

Comparison of the effectiveness of the two formats was based on accuracy and response times. I evaluated the overall effectiveness of the two lesson formats as well as the effectiveness of combining information presentation types. Attitudes of both dyslexic and non-dyslexic students to the two formats were also assessed.

The results from this study should identify potential benefits of utilizing multimedia to help students, in general, and dyslexics in particular, learn important geographic concepts. It was expected that the two methods of instruction would produce few differences for non-dyslexic students but the multimedia approach would ease frustration for dyslexic students and allow them to gain a knowledge base competitive with that of non-dyslexic students. It was also expected that as the number of combined information presentation types increased, the response times and accuracy would improve in both dyslexic and non-dyslexic students. On a more general level, this study should contribute to the growing knowledge of the advantages and disadvantages of interactive multimedia tools in geographic education.

Organization of the Dissertation

Having established the overall objective in this chapter (Chapter 1), Chapter 2 reviews several threads of literature from which the research has drawn. Chapter 3 lists the specific research questions along with the methods and procedures used in the experiment. Chapter 4 describes the geographic lesson used in this experiment, including how the information was compiled, the use of the geography standards, the creation of the text and multimedia format, and the revision of the lesson after a focus group evaluation. Chapter 5 presents the results from the student testing. A logit analysis was used on students' accuracy and response times to a posttest following the geographic lesson. Student attitudes toward the two formats are compared using results of the preference questions. Chapter 6 concludes by examining the testing considerations, recommending possible testing alternatives and future applications of the findings, and the significance of the results.

CHAPTER 2: LITERATURE REVIEW

Technological and philosophical developments have led to changes in the way cartographers create, utilize, and evaluate map products. Interactive multimedia, the increased priority given to geographic education in recent years, and the desire to create products for disabled populations are the three areas of change that I will review from the cartographic literature.

The array of articles pertaining to the potential teaching capabilities of interactive multimedia from diverse disciplines is overwhelming. Little research has been conducted on how interactive multimedia affects the learning of geography by dyslexic populations, but an extensive collection of literature from both applied and theory-oriented research in education, geography, psychology, and medicine has been compiled.

A review of recent trends in geographic education was necessary as one of the first steps in evaluating interactive multimedia as a geographic educational tool for today's goals and objectives. Several steps have been taken in the last two decades to enhance geographic education. This chapter will review developments in the importance of geographic education and in the prevalence of geographic teaching in the American school system. I will also discuss the educational support for utilizing interactive multimedia in the classroom.

It is important in this research to examine how geographers are beginning to extend the discipline to populations outside the usual able-bodied majority, and how maps have the potential to help some populations with disabilities overcome their impairments. There is evidence in the literature that there is a growing concern for a broader population.

I will finish this chapter defining dyslexia, reviewing some of the general characteristics of dyslexia, and reviewing some of the research oriented toward learning strategies for people with dyslexia. Studies of the effectiveness of multimedia for learning geography can draw upon a range of general research on dyslexia.

Interactive Multimedia

New cartographic products have developed over the last several decades as computer technology has become more prevalent and affordable. One example of a new type of cartographic product is interactive multimedia. Multimedia refers to information products that include a variety of forms, such as text, static images, animations, video, and sound. Interactive indicates that on-screen buttons and "hot text" are programmed to link information in a non-linear fashion such that the user can move from one set of information to another.

Numerous types of interactive multimedia products are commercially and academically available. Many are for pure entertainment while others are for learning. The availability of software for producing interactive multimedia has resulted in a proliferation of electronic atlases (Rystedt, 1995), which often combine textual materials with photographs, video and audio clips, animated illustrations and reference maps. Olson (1997) refers to multimedia as one of the most pervasive computer-related developments in contemporary cartography.

Krygier (1994) discusses improvements in personal computers that have made the memory requirements sufficient to create and run interactive multimedia products, and observes that the number of high-quality software packages for creating such products is increasing. Specialty books such as Peterson's *Interactive and Animated Cartography* (1995) have been appearing, and commercial software packages that can create interactive products (maps as well as others) and run animations are now available (Campbell and Egbert, 1990). Many of these programs can import images from both Macintosh and PC platforms and the programming in most of these packages is relatively easy to learn, yet it is sophisticated enough to create impressive interactive multimedia products (DesRoches, 1994). Currently, several available software packages, such as Macromedia DIRECTOR and CorelMOVE, can easily incorporate interactive slider bars, graphs, maps, and model simulations that respond to the actions of the user (Krygier, 1994).

Of the array of capabilities that interactive multimedia include, three are often considered by geographers because of their potential ability to transcend the traditional static map: sound, interactivity, and animation. DiBiase et al (1992) and Krygier (1994) argue that sound is a useful dynamic variable because it can be used to enhance the viewer's experience and provide proper pronunciation of unfamiliar words. Sound would decrease the need for written explanatory text, allowing the viewer to concentrate on graphic elements (Des Roches, 1994). Often in multimedia, sound is used to indicate a change between maps or graphs. MacEachren and DiBiase (1991) compare the introduction of sound into maps to the introduction of sound into the silent movie industry, and they state that the ability to talk viewers through spatial displays could have profound challenges to the visual imagination and technical adaptability of cartographers.

Interactive buttons allow one to use the map to access more information. Many geographers have commented on the importance and usefulness of interactivity. Carter (1988), MacEachren and DiBiase (1991), and Weber and Buttenfield (1993) claim that the ideal dynamic sequence should be truly interactive and allow the viewer to modify the speed of the animation, as well as to stop, back up, or replay sequences. Buttenfield and Weber (1994) believe the key to successful learning is in the viewer's ability to explore and engage spatial data, while Monmonier (1990) states that interactive maps allow the user to search for what they find interesting.

Animation is an interesting component to interactive multimedia because it allows the portrayal of changes over time of attributes on a map. Animation depends on the human ability to retain an image of an object shortly after it has been removed from the field of view. If a series of static frames is shown in rapid succession, approximately 30 per second, with each image changing slightly from the preceding one, the brain creates the illusion of a fluid-like motion (Campbell and Egbert, 1990). Successive versions of a map, like any other slightly changing object, appear to transform smoothly.

Although the literature on interactive multimedia comes predominantly from the 1990s, discussions of cartographic animation date back nearly forty years. The development of animation is often associated with Norman Thrower, who in 1959 published an article entitled "Animated Cartography." He explained in detail the procedure for constructing an animated film with the use of celluloid technology.

The introduction of computers in the following decades helped facilitate the production of animated maps and several noteworthy examples arose. Tobler (1970) designed a computer simulation of urban growth in Detroit, Michigan. More recently, just to mention two examples, MacEachren and DiBiase (1991) produced an animated map of the spread of AIDS in Pennsylvania, and Weber and Buttenfield (1993) animated surface temperatures for the United States.

The interest and success of the previously listed examples helped to promote the growing awareness and potential contribution of animation and interactive multimedia among geographers. One of the main display arguments for cartographic animation is that it presents information in a "natural" way. We are accustomed to seeing things move and change in space and time and thus for decades cartographers have considered animation a viable and useful technique for the detection of spatial patterns and temporal trends (Campbell and Egbert, 1990). Thrower (1959) felt that topics such as the spread of population, the development of transportation lines, the removal of forests, the modifications of political boundaries, the growth of urban areas, and seasonal changes in climate variables were particularly well suited for animation. MacEachren (1992) argues that animation is useful for showing relationships especially for those studying earth sciences where events occurring over time are critical to their exploration. Koussoulakou and Kraak (1992) also argue for its usefulness and state that animation is widely used in the Netherlands in the monitoring of water bodies.

The types of animated maps are numerous. Peterson (1995) classifies animations into two broad categories: temporal and non-temporal. The first type of animation, temporal, expresses the change in location of attributes over time. A few examples could include the spread of Lyme disease in Connecticut, the transport of hazardous waste along the Columbia River, or the migration of African swallows. In these animations the base map remains fixed and the locations or attributes of symbols move or change over time.

The second type of animation is non-temporal change. A common, non-temporal change is the viewer's position in an animated fly-by where the animation displays an image that gives the illusion of flying in an airplane over an area. Other non-temporal changes include viewer position with respect to a three dimensional object, such as the globe or a block diagram of a landform. Simple changes in scale created by zooming in or out on a map are a very commonly used form of non-temporal animation. These changes in zoom level, von Wyss (1996) claims, are particularly useful in the social sciences where it is important to look at information at many different scales.

In addition to Peterson's (1995) two broad categories of animations is a third type which uses movement to draw attention to an item whether or not any mapped feature changes temporally or non-temporally. Blinking symbols or flashing arrows that are superficial to the map help draw the viewer's attention to particular items that may be obscured, appear infrequently, or are not particularly large in size but still deserve notice.

With the variety of types and uses, and with the increasing availability of software to create animations, it is little wonder that animated mapping has become widespread in the 1990s. We are ready to put it to use in a variety of contexts and to test its potential as a tool to help teach geographic concepts.

Geographic Education

Changes in cartographic products and the increase in distribution of computers have occurred simultaneously with a resurgence in geographic education. Scholars, including Bednarz and Peterson (1994), have called this resurgence a reform movement and a time of great opportunity. Pivotal steps have been taken to increase the quality and quantity of geographic education and to develop successful curricula in the United States. A significant contribution of geography to education is the promotion of interesting, innovative teaching methods that motivate students, and many researchers have looked at the potential contribution of interactive multimedia as a potential educational tool.

Geography is an investigative and integrative discipline that brings together physical and human features and processes that shape the earth. Preston James (1969), in writing about the significance of geography in American education, stressed that for the young to become educated citizens in a democracy, they need skills to grasp concepts and knowledge to seek solutions to social problems. The important part of geography is not to learn the names and locations of places on the earth, but rather to learn why these places exist and the basics of how humans use, interact with, and affect their different environments. Geographic education should teach students to think spatially, to integrate different types of information and to express effectively their ideas to others.

Alarming reports about the low level of geographic knowledge by United States students gives ample evidence that geographic education in the past has been less than adequate (Bednarz and Petersen, 1994). Many geographers and educators have a growing awareness that a fresh, new approach to geography is needed to inform, inspire, motivate, and encourage students (Dymon, 1995).

Several notable steps have been taken to help bridge the gap between K-12 education, university geography, and employer needs and to educate today's youth for future success (Bednarz and Petersen, 1994). One of the most commonly-noted steps is the development of the guidelines established in *Geography for Life: The National Geography Standards 1994* (NGSP, 1994). Although the standards are followed on a volunteer basis, they provide teachers a foundation on which to plan curriculum and to measure their students' geographical performance (Bednarz and Petersen, 1994).

Other steps to improve the quality of geographic education have been taken by the National Geographic Society which has supported educational alliance networks across the United States (Dulli, 1994). Many K-12 teachers have little or no training in geography and have difficulty developing their own geography teaching materials. Geographical alliances provide workshops and curriculum materials to aid those educators teaching geography. The National Geographic Society also supports and promotes Geography Awareness Week to help give momentum to the efforts to improve geographic education.

Maps are fundamental in geography and should be a central element in geographic education. Downs et al. (1988) recommends that maps be integrated throughout K-12 education because they are central to the way people think and make decisions about their surroundings. Robinson (1967) discusses how a map can help guide individuals in understanding their environment. He says that geographic education must include map reading skills to create graphically literate citizens. Rice (1990) claims that the aim of social studies should be to train students to think critically, and having students analyze and critique maps will help the students become more discriminating individuals.

The empirical research on the effects of maps on student learning of geography spans over thirty years (Ramirez and Gilmartin, 1996). Gilmartin (1982) found that college students who read text material and view maps score significantly higher on test questions than those students who only read the text. In another study, Ramirez and Gilmartin (1996) found a similar pattern in scores on tests taken by seventh grade students. Although their results were not statistically significant, they felt that a distinct trend was present, with students who viewed maps along with text scoring higher than those students who read text only.

Interactive Multimedia in Education

Many researchers, including Rieber (1990) and Krygier et al (1997) have looked at the potential contribution of interactive multimedia as a potential educational tool. The importance of interactive multimedia packages as a potential learning tool in the 1980s and 1990s has increased as technology has become more affordable and accessible to both cartographers and students. As it has become more prevalent in classrooms, the question arises as to the educational benefits of interactive multimedia. Geographers and educators have discussed what is appropriate media to represent different types of information. They have hypothesized about how people learn and retain information and have studied empirical evidence from tests evaluating the educational potential of interactive multimedia.

Geography is an interdisciplinary subject that examines spatial relationships, and many geographers and cartographers have argued that interactive multimedia is a good medium to present spatial information. Since theme, location, and time are the three components of geographical data (Sinton, 1978), the capabilities of multimedia offer appropriate representational dimensions for all three components. Monmonier (1990), Dorling (1992), Karl (1992), and Koussoulakou and Kraak (1992) believe that packages that include animated maps provide a logical means for visual communication of geographical data.

Interactive multimedia products may also facilitate learning because they stimulate multiple cognitive processes. Berger, Pezdek and Banks (1987) argue that the integration of both verbal and pictorial information increases comprehension of information. They found that the combination of an audio track along with visual information improves viewers' comprehension and retention of information better than either mode (audio or visual) individually. This theory, Rieber (1990) explains, is often termed dual coding and is the idea that words and pictures activate independent verbal and visual codes for memory storage. A learner can encode the information into long-term memory using both verbal and visual channels, and the redundancy increases the probability of memory retrieval.

The findings of Amlund, Gaffney, and Kulhavy (1985) support this dual-coding cognitive system for the storage and retrieval of information. They believe that the human brain has one system for visual information and another system for verbal information and thus the dual coding of visual and verbal information enhances memory recall. Buttenfield and Weber (1994) state that multimedia expands the memory channels available to viewers for information processing. They feel that because the human sensory systems excel at specific tasks, dividing information among several sensory modalities may reduce the complexity of the overall message. Lanca and Kirby (1995) agree with the dual coding hypothesis and recognize the importance of verbal information with reference maps, but they do suggest that it may not be beneficial for all types of maps. Ramirez and Gilmartin (1996) point out that even if dual coding is not occurring in the brain, it may still be important to accompany text with graphics for the purpose of repetition. By displaying the information in both map and text form it provides the learner with more opportunities to understand and retain the information.

Another consideration for cognition and multimedia is the time involved in processing and storing information. Information processing is not instantaneous, but rather it goes through stages of presemantic memory, short-term memory, transient memory, and finally long-term memory with different levels of comprehension and retention at each stage (Monmonier, 1992). Interactive multimedia has the flexibility to include summary graphics that could refresh previously viewed information. Carter (1988), MacEachren and DiBiase (1991), and Weber and Buttenfield (1993) feel that increased retention of information would come from allowing the viewer to control the speed of the animation with the ability to flip back and forth between frames. They claim that the ideal dynamic sequence would allow the viewer to choose the speed of the animation, as well as be able to stop, back up, or replay the sequence.

Interactive multimedia has also been discussed as a potentially useful educational tool because of its ability to allow the students to direct their studies and explore geographic data sets using graphical observation (Buttenfield and Weber, 1994). Dymon (1995) states that electronic atlases, with their interactive capabilities, allow students to select, build, and design their own maps. Krygier et al. (1997) claim that multimedia is much more than just a new technology; it is an opportunity to change the way students think and learn.

With the increase in availability of personal computers and the prevalence of multimedia products, what are the actual empirical results of multimedia's effectiveness in the classroom? Several tests have been conducted on whether or not interactive multimedia products do indeed increase understanding and retention of geographic information.

Several studies found that student learning improved with the use of interactive multimedia. Collins, Adams, and Pew (1978) found that students learned significantly more with an interactive map display than with a static map. Rieber (1990) created lessons for fourth- and fifth-grade students and found that interactive maps are important in helping students visualize motion and changing spatial information. Proctor, Sutton, and Michaels (1995) also found that interactive multimedia improved student learning in an introductory human geography course. They felt that the student essays written after viewing the interactive multimedia modules demonstrated an advanced level of mastery of geographical concepts and skills.

Several studies found that there was no difference in student learning with the use of interactive multimedia. Koussoulakou and Kraak (1992) conducted a test comparing animated and static maps. The results showed no differences in correctness of answers between the two groups but the response time for animated maps was about half that for static maps. Milheim (1993) found that some animation had no positive effects over text or still graphics and in some cases it was seen as distracting.

The one consistent finding in almost all studies is the reported enthusiasm of students toward multimedia. Milheim (1993) provides a summary of studies focusing on computer lessons that include animation and multimedia. He recognizes that although there have been conflicting results relative to its effectiveness, the majority of studies comment on the technology's ability to motivate students. Edgeman (1994) supports this finding, as well. In her study there were no significant differences in the information retained by her subjects but users viewing the animated display were more receptive and enthusiastic than those viewing the static display. Buttenfield and Weber (1994) feel that the interactive component of multimedia brings out the natural curiosity of the user. Karl (1992) also comments on the enthusiasm component of interactive multimedia. She believes that people will find interactive multimedia packages exciting and dynamic, which in turn may rouse children's interest in geography.

Mapping for Special Needs

For centuries, mapping had a place at the forefront of exploration and geographical knowledge. Maps also show technical expertise on the part of the map maker and the society in which it was produced. Maps imply power and knowledge, act as data storage, and are a means of communication. This milieu for maps in which they affect and are affected by general human endeavors is most easily identified in the Renaissance period where new ship building techniques, tide tables, and almanacs facilitated exploration, which in turn resulted in circumnavigation of the world, charting new bays and territories, empirically mapping the coastlines of the world (Johnston, 1997), and in general facilitating the colonial era that would follow. The new technology and knowledge of the Renaissance spurred philosophical changes in economies, administration, and moral beliefs about peoples' places in the world. In the second half of the twentieth century, technological and philosophical developments also changed the way in which cartographers produce, study, and think about maps (Morrison, 1989).

Maps, most commonly, have been made for and by those in power. Some of the philosophical changes in the twentieth century have questioned the status quo and have looked at using geography and cartography to promote disempowered populations and utilize alternative methodological approaches. Behavioral and Marxist geographers, including Peet (1977) and Harvey (1973) urged the development of methods other than traditional mathematics and inferential statistics. Further, dissatisfied geographers in the late 1980s offered postmodernism, feminism, and more recently positionality, a philosophical approach that stresses local differences (Johnston, 1997). These philosophical trends attempt to promote the appreciation of uniqueness, while often examining the fundamental inequalities of race, gender, and class. Cartography is being influenced by these changing philosophies.

A major inequality that geography and society has begun to explore is that between people with some physical or mental disability and the general population. The treatment of disabilities has changed drastically in the course of human history. In a hunting-and-gathering or pastoral society, the old, weak, or handicapped person was a burden to society. Even more recently, throughout the industrial age, handicapped people were often excluded and separated from ordinary populations. Only in the last several decades has there been a different, more integrative approach to disabled populations, and indeed they are now acknowledged and even celebrated. Recognizing the United States as being an information-age society, there is little reason for disabilities to disempower people. Physical prowess is hardly required for economic and social success, and even cognitive impairments are understood as limits that can be overcome by use of human ingenuity.

Golledge (1993) defines a disability as a physical impairment that limits a person's ability to perform a specific task. A disadvantage, on the other hand, is when someone is unable to complete a task because of physical, cultural, ethnic, political, religious, or other social constraints. Many services and products are available so people with disabilities are not disadvantaged. Whether or not a disability becomes a disadvantage depends upon the individual's desires and society's actions including making available the assistance to overcome barriers.

The disciple of geography may be able to assist populations with disabilities. In the past, maps were generally created for the "average" map-reader with little consideration for those with disabilities (Golledge, 1993). Most studies of people's cognitive map reading abilities assumed a population with average cognitive development and processing abilities. Golledge (1993) urges geographers to use their expertise to identify similarities and differences between an average population and a disabled population. A general shift away from the focus on the average map reader should open the door to assistance rather than lack of attention. Furthermore, the tools and knowledge of geography may be especially useful to some people with disabilities.

A map is a useful tool for communication in geography, and it may be an even more powerful tool to someone with disabilities. Cartographic alternatives with disabilities in mind may enhance their abilities and prevent disadvantages. One successful example is the study by Olson and Brewer (1997) that looked at maps for people with impaired color vision. They found that by designing maps with accommodating colors they could greatly reduce, if not eliminate, the problems of people with red-green vision impairment. With appropriately designed maps, subjects could identify mapped colors and answer map questions with as much accuracy as those with normal color vision, and the response-time gap between the two groups was greatly reduced.

Ungar et al. (1997) looked at the spatial knowledge of blind and visually-impaired people. In their study, they worked with thirty visually-impaired adults who were blind from birth or were blind before the age of six. Participants were introduced to an urban environment in one of three ways: by direct experience, by studying a tactile map, or by hearing a verbal description. The three introduction methods did not affect the participants' overall representation of space, but the tactile map users were significantly more proficient at following and walking complex routes. The results may be no different than they would have been for sighted participants, but it illustrates the importance of the map as a medium for enabling blind persons to navigate.

Maps may also be useful for disabled people who have learning disabilities that make it difficult to study geography through formal written language. Amlund, Gaffney, and Kulhavy (1985) found that maps facilitate poor readers' recall of spatial information found in text. Birley and Tasker (1995) examined five different learning disabilities and found that maps can serve as a graphic translation of spatial information for those with difficulty in reading and writing. In addition to just maps and text, multisensory approaches that include sound have been successfully implemented in the public schools to help students with learning disabilities to improve their reading and writing skills (Vickery and Reynolds, 1987). Sound can potentially alleviate problems of understanding text and also supplement visually difficult words found in graphics. Such potential makes multimedia a plausible education tool that should be explored to help those with learning disabilities to acquire new knowledge and skills.

Dyslexia

It is generally agreed that many school children are not reading, writing and spelling as well as they should (Critchley, 1981). Some children, however, are not just developmentally slow or uninterested, but actually have a learning disability that inhibits their skills. Dyslexia is one such learning disability.

General Characteristics

Dyslexia is characterized by specific difficulties with written language, including reading, writing, and spelling (Catts, 1989). People with dyslexia typically have difficulty processing language into thought (reading or listening) and conversely, translating thoughts into language (writing or speaking).

The earliest symptoms of dyslexia are when children begin lagging behind peers during early reading lessons and when they are late in learning to name the letters of the alphabet. Reversals and inversions of letters are common characteristics. For example a "p" may be reversed and written as a "q" or inverted and written as a "b" or even reversed and inverted and written as a "d." Critchley (1981) points out that reversals, inversions, and rotations of individual letters and numbers persist long after other children have corrected these mistakes.

Throughout schooling, students with dyslexia have difficulty linking up familiar combinations of letters, such as *th* and *ight*. They tend to be reluctant to read aloud, and they avoid reading, writing, and spelling assignments. When dyslexic students do engage in a language assignment it generally takes longer, and, if pressured to speed up, they will tend to become less accurate. It is important to note that studies show no difference in the mean or variance of IQs between dyslexic and non-dyslexic students, nor do the students differ with respect to performance on visual, vocabulary, or memory measures (Critchley, 1981).

Critchley (1981) points out a few other symptoms that are commonly associated with dyslexia. One is the tendency to use incorrect words, such as officer for official, approximate for appropriate, and fingers for fringe. Another symptom is the substitution of synonymous or near synonymous words such as *beer* instead of *ale* and *buy* instead of *bought*. A symptom commonly found in older people with dyslexia is the tendency not to detect misspelled words. Even when the dyslexic reader is capable of spelling the word correctly, the mistake often goes unnoticed.

In most individuals, both spoken and written language is processed in the left hemisphere of the brain while the right hemisphere processes spatial activities and tactile recognition (Masland, 1981). Moats and Lyons (1993) report that the difference between dyslexics and non-dyslexics appears to be in the activated left- and right- brain regions during tasks related to reading. Students with dyslexia tend to process language in their right hemisphere. Critchley (1981) also notes that ambidexterity seems to be more common in dyslexics than non-dyslexics, which again is attributed to the difference in cerebral brain activity.

Dyslexia is found more or less equally among race, gender, ethnic, and economic groups, and is present from birth to adulthood. Increase in public awareness has resulted in more people being properly diagnosed (Moats and Lyon, 1993). Academic difficulties experienced by students with dyslexia in elementary and secondary settings persist into adulthood (Catts, 1989). Dyslexia does seem to be hereditary and there is usually a family history of similar problems with reading, writing, and spelling (Critchley, 1981).

Historical Overview of Identification and Provisions

Dyslexia is often termed an "invisible disability" because it is not easily detected and many of those who are dyslexic learn to compensate for their deficiencies by promoting their strengths in other skills. Only with the basic understandings of cognitive properties and some inferences on the workings of the human brain has treatment of dyslexia been possible. Previously, people with dyslexia were viewed as less intelligent, mentally slower, and often unmotivated. Only in the last two decades have they been recognized as equally intelligent with only a mental-processing difference. The identification and treatment of dyslexia has changed as knowledge of the inner-workings of the human brain has become more scientific and reliable. Current learning strategies for dyslexic students are founded on this growing knowledge of the human brain.

As early as 440 B.C. Hippocrates wrote that diseases such as epilepsy and stroke were products of disorders in the brain (Levinthal, 1990). With little empirical research and difficulty visualizing the brain's activities, Hippocrates' ideas were seldom acknowledged. It was not until the middle of the 1800s that researchers began to systematically examine the brain as the main organ responsible for physical characteristics and disorders.

In 1861, Broca established that aphasia, a language disorder, was the result of deterioration in the frontal lobe of the brain's left hemisphere. This discovery started the modern era of neuroanatomy and provided the physical basis for language (Levinthal, 1990). The origins of identification and treatment of dyslexia is attributed to Dr. Samuel T. Orton, who in 1925 integrated neurological and psychological research from stroke patients and those with reading difficulties (Rawson, 1981). He began multidisciplinary work collaborating with schools, clinics, and private practices. After his death in 1948, his work was continued by his wife, Jane Orton, psychologist Anna Gillingham, and teacher, Bessie Stillman. The Orton Dyslexia Society was founded in 1949. At the time it was the only open-membership, professional association devoted exclusively to problems of language-based learning disorders (Rawson, 1981).

Although research was being conducted on dyslexia, the condition was largely ignored in the late 1960s and 1970s by educators in both the United States and Great Britain (Miles and Miles, 1990). Even as late as 1975, a report aimed for British civil servants dismissed dyslexia and stated that it was incapable of a precise definition; rather, symptoms should be referred to as "specific reading retardation" (Critchley, 1981). Miles and Miles (1990) suggest that educators tended to be cautious about labeling a child dyslexic because it could imply a permanent stigma on the student.

Twenty-five years ago there were few alternative learning strategies, and dyslexic students had difficulties succeeding. Laws now mandate that K-12 children with learning disabilities have accommodations in every aspect of the regular education experience and have the opportunity to benefit equally from education. The Orton Dyslexia Society stresses a multisensory learning approach that stimulates all sensory pathways to the brain to enhance memory and to help the dyslexic student succeed.

Today, many students with dyslexia receive assistance from tutors and/or computer programs, always with a multisensory approach. Computer-assisted devices provide a liberating effect for dyslexic students and generally increase their productivity. Rather than the students falling behind because they are entangled with reading the materials, computer devices help build their knowledge and vocabulary (Moats and Lyon, 1993). If programs or trained tutors are not available, Rawson (1981) urges that parents and teachers read to dyslexic students to insure that they keep up with information that their peers are receiving. Alternative learning styles will, of course, not cure any disabilities, but they can enhance dyslexic student's knowledge and make their learning a less stressful experience. As they succeed in learning with alternative styles they will become more confident as students. As students gain skills, their tendency is to liberate themselves from aides and tutoring devices. Students with dyslexia share the same interests, desires, and capacities as their peers and generally want freedom from such encumbrances.

In 1995, Higgins and Zvi reported that over 100,000 learning disabled students graduate from high school every year and 67% of them plan to attend postsecondary institutions. These figures are evidence that students with dyslexia want to, and can, succeed in school. The numbers of students with dyslexia in the K-12 schools, and their aspirations for higher education, puts pressure on the public school system to provide them with a fulfilling education.

Interactive multimedia packages may be able to offer a number of potential benefits to dyslexic students that may facilitate their learning (Steeves, 1990). Interactive programs with hypertext allow the student to click on a word to get not only the pronunciation but also an explanation of its meaning in spoken language. CD-ROMs as well as the World Wide Web and other on-line educational services can provide vast amounts of graphics and sound that can enhance creative and investigative learning without the frustration of having to read large amounts of text. In this process, students utilize a variety of cognitive processes and acquire useful knowledge and skills.

Undoubtedly, several factors will determine the success of students with dyslexia. With all things being equal, the dyslexic with the higher IQ will have a greater chance of succeeding. Also, early diagnosis is useful, and a sympathetic and encouraging attitude by the parents and the teachers will most likely help. As in all educational success, personality traits on the part of the students with dyslexia and their determination to succeed and master difficult tasks will affect their degree of success.

Summary

In the last several decades, there have been overwhelming technological changes, which have led to changes in all scientific disciplines. This chapter reviewed the development of interactive multimedia in cartography and in education curriculum, along with its potential learning benefits for dyslexic students. Powerful personal computers and an array of software programs have made interactive multimedia readily available to cartographers. Interactive multimedia is an appropriate medium to represent spatial information and it seems to evoke enthusiasm on the part of students; thus it seems plausible that it would be a good educational tool to help teach geography.

The technical changes coincided with a resurgence in geographic education. Teaching aides and geographic standards have been prepared and suggested, helping educators improve the quality and quantity of geographic education. Maps, in particular, have been noted as fundamental, and particularly useful, in teaching K-12 student about their environment. Recent studies have begun to look at the importance of bringing interactive multimedia into the classroom to facilitate learning.

Developments in psychological and medical research on the human brain have aided geographers in understanding how people read maps and learn geographic concepts. Many of these developments can target specific populations. Dyslexic students, research has shown, benefit from learning in a multisensory fashion. By presenting information in a variety of formats (text, sound, and graphics) it stimulates multiple learning pathways to the brain and enhances memory. Interactive multimedia has capabilities for presenting information in a multisensory way and therefore may be a beneficial tool for teaching geography to students with dyslexia.

CHAPTER 3: METHODS AND PROCEDURES

This study was undertaken to test the usefulness of multimedia as an educational tool for presenting geographic material to eighth grade students with dyslexia. The same material was presented to non-dyslexic eighth grade students to compare effects. Utilizing a geography lesson that was developed in two formats (traditional text and interactive multimedia) the assessment of the effectiveness of the two formats was based on accuracy, response times, and attitudinal reactions of both the dyslexic and non-dyslexic students. This chapter outlines the research questions posed and describes the methods and procedures used in the study. A brief description of the materials (the development of materials is covered in detail in chapter 4) is followed by the methods used to categorize the information presented to the students. The chapter will conclude with a description of the student testing procedures and methods of analysis.

Research Questions and Specific Expectations

Five main sets of questions were posed in the research and each was associated with a specific expectation:

1. Accuracy

    1a. Does the multimedia format help a dyslexic student answer test questions with greater accuracy than the traditional text format?

    1b. Does the multimedia format help a non-dyslexic student answer test questions with greater accuracy than the traditional text format?

    1c. Does it help the students with dyslexia more than the non-dyslexic students?

Expectation: Multimedia will help dyslexics. If it helps non-dyslexics as well, the effect will be less than for dyslexics.

2. Response Time

   2a. Does a dyslexic student respond to test questions more quickly after using the multimedia format rather than the traditional text format?

   2b. Does a non-dyslexic student respond to test questions more quickly after using the multimedia format than after the traditional text format?

   2c. Does the response time improve more for the dyslexics than for the non-dyslexics?

   Expectation: Multimedia will help dyslexics respond to questions more quickly than traditional text. If it helps non-dyslexics as well, the effect will be less than for dyslexics.

3. Presentation Types and Accuracy

   3a. Does the accuracy of responses from a dyslexic student increase as the number of combined information presentation types increases?

   3b. Does the accuracy of responses from a non-dyslexic student increase as the number of combined information presentation types increases?

   3c. Does the increased number of presentation types increase the accuracy of dyslexic students more than the accuracy of non-dyslexic students?

   Expectation: A higher number of presentation types will increase the accuracy of dyslexic students and non-dyslexic students. The effect, however, will be greater for the dyslexic students.

4. Presentation Types and Response Times

    4a. Do response times increase for dyslexic students as the number of combined information presentation types increase?

    4b. Do response times increase for non-dyslexic students as the number of combined information presentation types increase?

    4c. Do response times increase more for a dyslexic student than for a non-dyslexic student as the number of combined information presentation types increase?

    Expectations: The increased number of combined information presentation types will help dyslexic students and non-dyslexic students increase their response times. The effect is expected to be greater for the dyslexic students.

5. Preference and Overall Enthusiasm

    5a. Do dyslexic students prefer or express enthusiasm about one format over another?

    5b. Do non-dyslexic students prefer or express enthusiasm about one format over another?

    5c. Is there a difference in enthusiasm between dyslexic and non-dyslexic students toward one format over another?

    Expectations: While it is expected that all students will express preference for the multimedia format over traditional text, it is expected that there will be greater enthusiasm from the dyslexic students than the non-dyslexic students toward the multimedia format.

The Geographic Materials

A geography lesson created both in a traditional text format and in a multimedia format focused on Michigan's coastal dunes. Both formats included graphics such as maps, pictures, and diagrams. The content of the lesson was divided into four sections, of roughly equal length, allowing an experimental design in which each student was exposed to two sections in the traditional text format and two in the multimedia format. The completion of the four sections exposed the student to the holistic nature of geography rather than to a narrow sub-area such as dune geomorphology. The geography education standards were considered in compiling the material, and the lesson addressed several of the standards.

The traditional text format was printed on 8.5 x 11 inch paper. Each section was approximately 6-8 pages in length including text, maps, and pictures. Due to the high costs of printing and copying color maps and photographs, the number of images in the traditional text format was limited, which is typical of the format. In this format, most of the information was encoded in the text.

Students were to proceed through this format the way they would normally read a textbook. They were to read each section, page by page, and examine the graphic images. Although individual students would have different reading skills, each section was designed to take approximately 15-20 minutes.

The interactive multimedia format was presented on a seventeen-inch computer monitor with an 800- by 600-pixel resolution. Students were to proceed through the lesson by selecting on-screen buttons. In addition to static maps, graphs, images, and text there were animated maps and audio sound bites. The number of images was more generous than in the text format, as is typical with interactive multimedia. Again, individual times would differ, but each section was designed to take 15-20 minutes.

The multimedia format was created using a program called Macromedia DIRECTOR for a PC Windows environment and the final product was stored on a CD-ROM. The lesson was stored as Projector files, as they could then be distributed and played on any Windows machine, regardless of whether or not the computer had the DIRECTOR program.

Evaluation of the Number of Information Presentation Types

Students viewing either format of the lesson were exposed to information displayed in a variety of presentation types, such as text, maps, diagrams, and pictures, and only animation and sound were unique to the computer format. The information students could attain from the geography lesson, therefore, needed to be placed into categories, and the four used were text, graphics, audio, and process.

Text, or written presentation, includes three subtypes that differ in appearance and content. The first is key words, such as map titles and place names, graph axes, and major section headings. The second is explanatory notes such as image captions or legend captions. The third type of text information is the narrative, or the main body of written material.

Graphic presentation includes two main subtypes, spatial and non-spatial. This division isolates information that varies conceptually as well as in selection, abstraction, and generalization. The spatial graphics include maps (selective representation of spatial features) and pictures (analogic representation of spatial features), whereas the non-spatial graphics include graphs and diagrams (the space within the graphic is used to represent non-spatial information).

Audio presentation includes three main subtypes. The first is audio explanation, which includes oral descriptions of the information that may range from one or two sentences to entire paragraphs. The second is oral key words or phases, including titles, headings and unusual or difficult names that appear in text, maps, graphs, or diagrams. The third is supplemental sounds, such as birds chirping, wind howling or waves crashing on the shore, which may allow the viewer to make inferences or to create associations that may enhance the retention of other information, or they may simply influence overall enthusiasm.

Process presentation is that which represents an action or changes over time and space. It is divided into two subtypes. The first, the static form, is composed of successive snapshots of different stages of a process. The second, motion, is either an animated map or video clip.

The inherent limitations of the two formats, traditional text versus multimedia, determines the way information can be presented. The traditional text contains the three variations of text, the two types of graphics, and the static form of process presentation. The interactive multimedia contain all types: text, graphics, audio, and process.

In addition to these four main categories, information in the lesson was often presented in a combination of two or more. The four single category types can be combined into six pairs, three triplets, and one set of four. Table 3.1 lists the possible numbers and types of possible combinations.

Number of Combinations	Combination of Presentation Types
1) One type	1.1. Text only 1.2. Graphics only 1.3. Audio only 1.4. Process only
2) Two types	2.1 Text and graphics 2.2 Text and audio 2.3 Text and process 2.4 Graphics and audio 2.5 Graphics and process 2.6 Audio and process
3) Three types	3.1 Text, graphics, and audio 3.2 Text, graphics, and process 3.3 Graphics, audio, and process
4) Four types	4.1 Text, graphics, audio, and process

Table 3.1: Numbers and combinations of presentation types.

The number of presentation types received may affect a person's ability to gain and retain information. It was recognized that the results of a test given to the students to determine the effectiveness of the traditional text versus the multimedia must take into consideration the number of presentation types. It was necessary therefore, to evaluate the questions for the number of presentation types by which the information might have been received. It was hypothesized that number of presentation types would have an effect on the student's scores on the test. Test questions given to students were identified and recorded with the combination code (e.g., 1.2 or 3.4) of ways in which they might have learned the answer. The test questions are listed in Appendix B and the list of identified combination codes for the test questions is displayed in Table 3.2.

Section 1

Question #	Traditional Text	Multimedia
1	1.1 Text Only	4.1 Text Graphics, Audio, and Process
2	1.1 Text Only	2.1 Text and Graphics
3	2.1 Text and Graphics	2.1 Text and Graphics
4	1.1 Text Only	2.2 Text and Audio
5	2.1 Text and Graphics	2.1 Text and Graphics
6	2.1 Text and Graphics	2.1 Text and Graphics
7	2.1 Text and Graphics	3.1 Text, Graphics, and Audio
8	2.1 Text and Graphics	1.1 Text Only

Section 2

Question #	Traditional Text	Multimedia
1	1.1 Text Only	1.4 Process Only
2	1.1 Text Only	3.3 Graphics, Audio, and Process
3	1.1 Text Only	3.2 Text, Graphics, and Process
4	2.1 Text and Graphics	3.3 Graphics, Audio, and Process
5	2.1 Text and Graphics	2.2 Text and Audio
6	2.1 Text and Graphics	3.1 Text, Graphics, and Audio
7	1.1 Text Only	1.4 Process Only
8	2.1 Text and Graphics	3.3 Graphics, Audio, and Process

Section 3

Question #	Traditional Text	Multimedia
1	2.1 Text and Graphics	3.1 Text, Graphics, and Audio
2	2.1 Text and Graphics	3.1 Text, Graphics, and Audio
3	1.1 Text Only	1.1 Text Only
4	2.1 Text and Graphics	2.1 Text and Graphics
5	2.1 Text and Graphics	2.1 Text and Graphics
6	1.1 Text Only	1.1 Text Only
7	2.1 Text and Graphics	2.1 Text and Graphics
8	2.1 Text and Graphics	2.1 Text and Graphics

Section 4

Question #	Traditional Text	Multimedia
1	1.1 Text Only	1.1 Text Only
2	1.1 Text Only	2.2 Text and Audio
3	2.1 Text and Graphics	3.1 Text, Graphics, and Audio
4	1.1 Text Only	1.1 Text Only
5	1.1 Text Only	3.1 Text, Graphics, and Audio
6	1.1 Text Only	1.1 Text Only
7	2.1 Text and Graphics	3.1 Text and Graphics
8	1.1 Text Only	4.1 Text Graphics, Audio, and Process

Table 3.2: Combination codes for the test questions in each of the four sections.

An example of separating test questions by combinations can be seen in the first section of the Michigan dunes lesson. In the traditional text, the student reads that Michigan has over 3,200 miles of coastline. This information is presented in text only (1.1). In the multimedia format, the student views a tape measure animated around the Upper and Lower Peninsula of Michigan measuring out 3,200 miles. Once it is measured, the student views the written text giving the length of the coastline and a voice emphasizes the number 3,200. In this format, this particular piece of information is presented in text, audio, and process animation (3.4). In the evaluation of information gained and retained, test questions were separated to reflect the number of combinations and the specific presentation types.

A compilation of the number of questions by combinations of presentation types appears in Table 3.3. While the number of presentation types is relatively well distributed within each format, it becomes obvious in the table that specific combinations were not sufficiently represented and some combinations were not represented at all. For example, text only was represented by 15 questions while audio only was never represented in the text version.

Although it would be desirable to include both the number of presentation types and specific combinations in the analysis, it was recognized that the proposed testing methods would not accommodate that level of detail. The number of questions needed to sufficiently separate out specific combinations, such as text and graphics vs. text and sound, would have been overwhelming to the students taking the test. It would also have been difficult to build the geography lesson to cover all possible combinations, and hence only the number of presentation types, not the combinations, was retained as a variable in the study.

Presentation Type	Traditional Text	Multimedia
1.1 (text only)	15	6
1.2 (graphics only)	0	0
1.3 (audio only)	0	0
1.4 (process only)	0	1
Total: 1 Presentation Type	**15**	**7**
2.1 (text and graphics)	17	8
2.2 (text and audio)	0	3
2.3 (text and process)	0	0
2.4 (graphics and audio)	0	0
2.5 (graphics and process)	0	0
2.6 (audio and process)	0	0
Total: 2 Presentation Types	**17**	**11**
3.1 (text, graphics, and audio)	0	7
3.2 (text, graphics, and process)	0	1
3.3 (graphic, audio, and process)	0	3
Total: 3 Presentation Types	**0**	**11**
4.1 (text, graphics, audio, and process)	0	2
Total: 4 Presentation Types	**0**	**2**

Table 3.3: Number of questions, by format, of the combination of presentation types.

Student Testing

Twenty-four dyslexic and twenty-two non-dyslexic eighth grade students studied the Michigan dunes geography lesson and were tested on its content. The students answered multiple choice questions in a pretest and on four section tests. Both accuracy and response times were recorded. All questions and multiple choice answers were given orally as well as visually by the computer in an attempt to minimize any reading disparities between subjects on the tests; any differences then, should be attributable to the nature of the lessons and not the delivery of test questions. All four multiple choice answers were displayed on the screen before the students could select a button. This prohibited students from answering questions before all four choices were given. The appearance of the text on the screen may still favor those who excel in reading skills but it does not favor them to the degree that a read-only test would.

To gauge the prior level of knowledge about the subject material, the students were given a pretest prior to the start of the lessons. Two different pretests were given, one to half the dyslexic students and half the non-dyslexic students and the second to the remaining half of each group. The test questions were divided into two tests so that any one student would not be overwhelmed at the start of this study by having to answer so many questions on a potentially unfamiliar topic. Each pretest consisted of sixteen lesson-related items and four more geography items, such as "The foreign country bordering Michigan is..." and "The capitol of Michigan is..." These latter items were included to make the pretest easier and to keep students from feeling discouraged, since many of the dune questions were likely to be on unfamiliar material.

Each student then completed two sections of the lessons in each format (four sections in all). The order in which they proceeded through the lesson was as follows: half the dyslexic and half of the non-dyslexic students completed Section 1 in the traditional text format, Section 2 in the multimedia formation, Section 3 in the traditional text, and Section 4 in the multimedia format. The other half of each group completed Section 1 in the multimedia format, Section 2 in the traditional text format, Section 3 in the multimedia format, and Section 4 in the traditional text format. The alternating design for the two groups was to eliminate any potential learning or familiarity improvements with the two formats, and the order of viewing the two formats was not expected to affect the results.

A test consisting of eight questions was administered after each of the four sections. The eight questions were identical to eight questions given in the two pretests. Since any given student only completed half the pretest questions, four of the questions in each section were repetitive and four were new to that individual. The questions were in a different order from those in the pretest.

Due to the nature of a multiple choice test, the answers to questions were limited. Questions did not have the student recall information, such as "Draw a picture of a parabolic dune." Instead, recognition questions were used, such as "Which picture below represents a parabolic dune?" In Section 1 and Section 2, two of the eight questions were what Manson (1973) refers to as *remembering* questions. In these four questions, the student was presented the information in the section and had to remember facts or ideas. The remainder of the four questions engaged the students in processing the information.

The students were asked questions that required them to synthesize or to understand the information in a context different from the one in which they had learned it.

The student testing ended with a list of on-screen preference questions. A series of adjectives, such as interesting, boring, and trustworthy, appeared one at a time on the screen. Students were asked to select which format they felt the word best described. They had four choices: the traditional text, the multimedia, both, or neither. After completing these preference questions, the student was also encouraged to speak freely about their reactions to the two formats and to comment on the overall testing procedure. This discussion was taped to avoid hindering the conversations by having to take written notes.

The dyslexic and non-dyslexic eighth grade students were recruited on a volunteer basis from the Grand Traverse Dyslexia Association (GTDA) in conjunction with the Traverse City, Michigan, public schools. GTDA was chosen for this study because it is a member of the Orton Dyslexia Association and it is the only dyslexic program incorporated into a public school system in the state of Michigan. Testing materials were given to the students in consultation with their teachers to best fit the curriculum and cause minimum disruption to classes. Teachers as well as students were cooperating on a volunteer basis.

The student testing was completed individually in a separate testing room to avoid distraction to students being tested or to the other students. The test administrator remained present in the room in case technical problems arose but did not provide any other forms of support. The students proceeded at their own speeds and could take as long as needed to complete each section.

Analyzing the Results

Results included the accuracy, response times, and attitudes of dyslexic and non-dyslexic students who completed the geography lesson in the two formats. The pretest and posttest questions were to be analyzed using a paired T-test to see if there was improvement after proceeding through the lessons. The accuracy results were to be subjected to logit analysis and the response times to analysis of variance (ANOVA). Logit modeling allows determination of which variables have a strong influence on right/wrong answers. Expected results were that, beyond pretest-posttest improvement, the presentation type, lesson format and the dyslexic/non-dyslexic status and the interaction between them would be the strongest influences. Because of the large data set (over 1300 answers in all) the Bayesian information content (BIC) statistic was applied to evaluate fit of the models. The same variables were expected to show an influence in the ANOVA. Chapter 5 describes the data set, variables, and statistical analyses.

Summary

A geography lesson was created in two formats: traditional text and interactive multimedia. It was to be tested on dyslexic and non-dyslexic students to identify potential benefits of multimedia as a learning device to help students, especially those with dyslexia, to learn geographic concepts.

The students' accuracy, response times, and attitudes were to be recorded to evaluate the effects of the variables in helping students gain and retain information. The inclusion of a multisensory approach, combining two or more presentation types, was expected to be particularly important for students with dyslexia. It was expected that the two formats would produce weaker, if any, differences for non-dyslexic students.

CHAPTER 4: THE GEOGRAPHY LESSON

The four sections of the eighth grade sand dune lesson created for this research project contained a variety of information. Considerable time and effort went into the product to make it a potentially worthy expenditure of time on the part of the students participating and exemplary of what students should be learning. A secondary goal was to have the product used after the research testing was completed. The entire lesson is included in Appendix A in both formats.

The four sections of the lesson covered four logical themes. Section 1, Location of Michigan Dunes, covered basic definitions and dune locations within the state. Special attention was given to dunes in state parks and designated national lakeshores. In this section, the general characteristics of the dunes located on the different Great Lakes were explained. Section 2, Geology and Geomorphology of Coastal Dunes, discussed the formation, geology, geomorphology, and succession of the dunes. The concepts of glaciation and lake level changes were explained. Section 3, Plant and Animal Life on the Dunes, explained the plant, animal, and bird inhabitants. Native species as well as introduced species and their destructive effects on the native ecosystem were included in this part. Section 4, Dune Protection and Sustainable Maintenance, explained the importance of dune protection and the need for sustainable use of dunes in the Great Lakes region, an important industrial hub and recreational area. The need to balance current and future societal demands while protecting the environment is a general theme in modern society and it was applied to dunes in this section.

Data Collection for the Lesson

The data for the development of materials came from course work completed at Michigan State University, from on-site fieldwork, and from additional textbooks, journals, and newspaper articles. The on-site fieldwork involved sketching diagrams, taking pictures, observing visitors, and walking around the State Parks. On-site data collection occurred between October 1996 and January 1998, with the majority occurring in the summer months of June-August 1997.

Most of the data were collected in State Parks and National Lakeshores for several reasons. First, Michigan has 96 State Parks, of which 20 are dedicated to protecting the coastal dune environment, and two National Lakeshores, which make up most of the environment about which the lessons were being written. Second, many of the State Parks and National Lakeshores have posters, brochures, and learning centers explaining dune characteristics and history of the area. These materials are substantial sources of information about what one is observing in the environment. Third, the State Parks and National Lakeshores have public access with only a minimal entrance fee. This not only allowed for data collection for the lesson but featuring public parks also teaches the students the location of good places to observe dunes if they are inspired to visit and learn more.

In some instances, surrogate measures were used to collect data. For example, collecting data on the animal population often came from observing footprints and tracks on the ground, claw marks on trees, or nesting sites. Many of the animals, because of fear of people or nocturnal habits, are not observable directly. Park rangers were especially helpful in pointing out evidence of animal life and explaining daily and seasonal behaviors.

Curriculum Justification for the Lesson

The dunes lesson was designed around a selection of national geography standards (Geography Education Standards Project, 1994). Eighteen standards that fall within five themes are described in the Standard Project. They include geographic knowledge and skills that students should have acquired by the end of the fourth, eighth, and twelfth grades.

The content of the Michigan dunes geography lesson exposes the students to material reflecting all eighteen of the standards. Table 4.1 lists the eighteen and indicates which sections of the geography lesson relate to each. For example, the first three

Standard	Section	Standard	Section
1. Maps, Tools, and Technology	1, 2, 3, 4	10. Cultural Patterns and Mosaics	4
2. Mental Maps	1, 2, 3, 4	11. Networks of Economic Interdependence	4
3. Spatial Information	1, 2, 3, 4	12. Settlement Patterns and Processes	3, 4
4. Characteristics of Place	1, 2, 3, 4	13. Geopolitical Cooperation and Conflict	4
5. Regional Patterns	1, 4	14. Human Modification of the Environment	3, 4
6. Culture, Experience, and Perception	3, 4	15. Physical Systems Affecting Human Systems	2, 3, 4
7. Physical Processes	2, 3, 4	16. Use, Distribution, and Importance of Resources	3, 4
8. Ecosystems	3, 4	17. Applying Geography to Interpret the Past	2, 4
9. Distribution and Migration of Populations	3, 4	18. Interpreting the Present and Planning the Future	2, 3, 4

Table 4.1: List of geography standards and the section(s) reflecting them in the Michigan dunes geography lesson.

standards, which examine the world in spatial terms with maps, tools and technologies are reflected in all four sections of the lesson. Standard #7, physical processes, is included in three of the four sections, as is Standard #8, ecosystems. Standards #17 and #18, applying geography to interpret the past and plan for the future, are reflected in sections two and four, and two, three, and four respectively.

Characteristics of the Formats

The traditional text format was printed on 8.5 x 11-inch paper. Each section was 6-8 pages in length including title page, text, maps, and pictures. An attempt was made to keep the four sections as consistent in style as possible. The title page of all four sections includes, in addition to the title itself, a large picture and a list of 3-5 main topics that are included in that section. In the traditional text format, the students received most of their information by reading the text, but almost every page had a color photograph, map, or diagram. Although individual students had different reading skills, each section was designed to take approximately 15-20 minutes, on average.

The multimedia format, as in the traditional text format, maintained a stylistic consistency between the four sections and within each section. The movie size filled most of the seventeen-inch monitor. The graphical user interface (GUI) for all four sections was the same. A top and bottom bar bordered the entire presentation. These bars were filled with an image related to the topic of that section. For example, in the plant and animal section, the bar was filled with dark green foliage with pale yellow flowers. Within the top bar, the title of the section appeared in the same place and in the same font for each section.

The main portion of the GUI was reserved for graphic images, and the section on the right-hand side was reserved for text, as shown in Figure 4.1. If text appeared in the graphics portion of the GUI, it was always placed in a gray box to ensure that it would stand out from the images. With the exception of main headings and text on images, all the descriptive text was displayed in the same font and size.

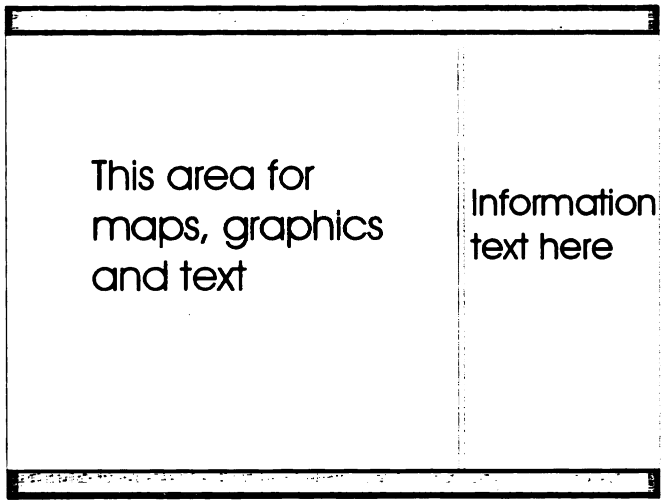


Figure 4.1: Generalized model of the multimedia format.

Similar to the traditional text, the first page of each section in the multimedia format consisted of a large picture, the heading, and a list of main topics covered in that section. Students were informed on this first page that they were to view everything on the screen and then proceed to the next screen by selecting the "next" button. The "next" button always appeared in the same place throughout all four sections. In a few cases, students were asked to select buttons other than the "next" button. In these instances, a red animated arrow traveled across the screen and indicated to the student the button they were to select.

Headings and color were used to indicate to the student where they were within each section. A heading for each of the main topics, such as "Origins of the Sand" or "How Dunes Form," was always displayed above the text to let the student know the current section. In addition, the background color remained the same in each of the screens within a main topic. For example, the background color for all pages pertaining to "Origins of the Sand" had a background color of pale blue, whereas the pages that discussed "How Dunes Form" had a background color of pale yellow.

Format of Test Questions and Response Recording

The test questions were also created using Macromedia DIRECTOR because of questions could be posed visually and orally, and student answers could be recorded along with the time required to answer each question. The recording of answers and time was accomplished by using the scripting language Lingo. During a DIRECTOR movie, all events, such as mouse clicks, are sent to the non-visible message window and are recorded using a Lingo command. When that Lingo command is scripted into objects and they are selected by the student by clicking on the mouse button, the hour, minutes, and seconds that correspond to the computer system's internal clock are recorded. During the four section posttests, Lingo was used to record the time the question was posted on the screen and the time of the student's answer. The subtraction of the latter time from the first time equaled the student's response time.

The subject's answers to the test items were also recorded in the message window by the same scripting language. The answer buttons were labeled by commands such a "put 'answer 1'". Different objects have different scripting codes, and thus it was easy to identify and record the answers for each subject. At the end of the test, the message window containing the student's times and answers was selected and imported into a word processing and spreadsheet program.

Evaluations and Revisions to the Lesson

A full draft of the geography lesson was evaluated by teachers and tutors of students with dyslexia. Evaluation comments were valuable in revising and refining materials. Not all of the suggestions could be utilized, but a number of comments are insightful into the analysis of the test responses and will be useful for future lesson development.

Evaluation of Lesson from Teachers and Tutors

A focus group of four teachers and tutors of dyslexic students was used in this study for evaluation of the draft of the lessons prior to student testing. Focus group participants were solicited from the Grand Traverse Dyslexia Association in Traverse City, Michigan. All participants were paid $25 and were given a set of the educational materials in both formats. The small number of participants was deemed adequate for the intended purpose.

The comments elicited from the teachers and tutors were to reveal areas, tasks, or concepts that might give students difficulty in ways unrelated to the goals of the research. For example, if a definition in the lesson used a word unfamiliar to students at the eighth grade level it might prevent everyone from understanding the content, thus masking any differences between groups. Participants of the focus group did not need to be familiar with geography, coastal dunes, computers, or interactive multimedia, but rather I needed input from people with a grasp of the level of knowledge, development, and capacity of eighth grade students, both dyslexic and non-dyslexic.

The focus group was a one-session event that took two and a half hours. The participants viewed the Michigan coastal dunes geography lesson in both formats, and they looked at all the test questions. This study of the materials was completed individually and took approximately one hour. All participants then engaged in a discussion for approximately an hour and a half. The participants requested that they have both formats in front of them during the discussion. The group sat around one computer and had Section 1 in front of them in both formats, and thus, although the discussion was generally about the two formats, specific details focused on Section 1.

I served as the facilitator and attempted to keep discussion going among participants and made sure everyone had the opportunity to express thoughts about the two lessons. The conversation was directed, but not limited, to a few main questions given to the participants after viewing the two formats (Table 4.2). The discussion was tape recorded and transcribed to help me evaluate the discussion afterward.

Participants were allowed to speak freely and answer the questions in any order. The overwhelming majority of discussion was directed toward question three: "What is your opinion of the multimedia approach to re-enforcing concepts by combining presentation types, such as graphics, sound, and text?" All the participants agreed that the maps and pictures in the multimedia would really help students, particularly those with dyslexia, learn the concepts. One example to which they reacted positively was Section 1's description of the general characteristics of the Great Lakes. They felt that having a Great Lake blink and then move to one of the corners, accompanied by three pictures of its coastline, would reinforce the learning of the place's characteristics. They felt that the students would not learn this concept as well in the traditional text format. One participant said, "For both dyslexic and non-dyslexic students, the visual aspects of the multimedia should really help them learn it." Another participant agreed and said "I love the moving arrow in the state park tour, this is much better than in the text part."

Focus Group Questions
1. Do you feel some students may have difficulty understanding the content of the lesson in: a. Section 1 b. Section 2 c. Section 3 d. Section 4 2. Do you feel some students may have difficulty understanding the: a. Static maps and diagrams b. Animated maps and diagrams 3. What is your opinion of the multimedia approach to re-enforcing concepts by combining presentation types, such as graphics, sound, and text? 4. What questions, or what type of test questions do you feel will give students the most difficulty? 5. What would be your biggest concern with dyslexic students viewing this material? 6. What changes would you make within each format?

Table 4.2: Main questions asked by the facilitator during the focus group evaluation.

The inclusion of sound in the multimedia also elicited comments. All the participants were enthusiastic about having the text read aloud. They felt this approach would be a way for the students with dyslexia to grasp major concepts, rather than become stuck on particular words and then not understand what they were reading. One participant strongly urged that the entire lesson be read aloud.

While all the participants liked the inclusion of sound bites narrating the text in the multimedia format, they were concerned with ensuring that it could also be muted. In a classroom with twenty to thirty students, they felt that the verbal text might be distracting to other students. In addition, the tutors were particularly concerned that attention deficit disorder students would learn less because they might be distracted by the sound while they were trying to read. All four participants agreed that information should never be presented by sound only, but always in conjunction with text. They felt it would help reinforce reading skills.

The participants felt that the content of the lesson was appropriate for eighth graders, and they thought that eighth grade students would enjoy learning about dunes. They thought each of the four sections would be a nice lesson or module for a teacher to cover in a classroom. They also thought that the lesson could be more inclusive. For example, they wanted to learn about all the state parks, not just a few (an example of a suggestion that could not be implemented in this lesson). In addition, they wanted to go back and re-visit the parks and compare their characteristics. They did not want the lesson to follow such a linear path.

The time required to go through all four sections of the lesson was noted by all participants. They showed concern for the length and thought that it was too much material for any one student to learn at one time. A participant said, "You might find students will get bored and distracted toward the end. The dyslexic students particularly might start to slow down."

One suggestion that was given to alleviate the problems with too much information was to interject questions from time to time. It was noted that another program, Accelerated Readers, has the student read a passage and then answer questions. This was viewed as beneficial from a teaching perspective because the computer could then record answers and assign grades. As to student's skill with reading graphics, the participants felt that there would be no problem with the students understanding the maps, graphs, or diagrams. It was suggested that the one graph in Section 1, describing the number of visitors annually, use the same number system for all values (an example of one of the suggestions that was implemented in the final draft). The graph had the numbers 100,000 and 1.25 million, and the tutors thought that this might give the dyslexics some difficulty and might even lead some students to thinking that 1.25 is the smaller number.

The focus group participants had viewed the test questions after looking over all four sections. While they felt they were good questions, they thought that the synthesizing ones might give the students some difficulty. The participants were not informed as to which questions were the "remembering" questions and which were the "synthesizing" questions, but, not surprisingly, they noticed the difference. They suggested that the synthesizing questions be placed last with the words "bonus question" indicating that the student may need to think a bit harder.

All the participants liked the way the questions were read to the student by the computer and thought this would help to eliminate any reading problems during testing. They also commented on the way that the student moved the mouse to select an answer. They felt this would help to eliminate problems of confusion between choosing an incorrect answer and merely marking down the answer incorrectly. Dyslexic students often mix up their letters when taking multiple choice exams and write down "b," for example, when they mean to write down "d."

The Revisions

The suggestions and comments given by the participants of the focus group were insightful and helpful, and some revisions were made to the lessons based upon them. The teachers found a few editorial mistakes that were immediately corrected. Based on their recommendations, the tempo of the multimedia was slowed down slightly and a few extra seconds were added between the time that the text appeared and the time that the photographs appeared on the screen.

Many of the comments made during the focus group will be useful for someone creating future interactive multimedia for eighth grade students, and most would probably have improved the multimedia format of the Michigan dunes lesson. Many of the suggestions, however, could not be incorporated at this time due to the constraints of the testing design. Having sound throughout the lesson was suggested, for example, and the participants thought it would be more interesting and beneficial to the students. The test questions, however, were created to distinguish information gained by the student through text, graphic, sounds, and process; thus, it could not be changed. The length of the test was also not possible to change. Scheduling students to take the test was difficult and time consuming. Asking students to take one section one day and return another day to take another section was not feasible. It was also important that one student complete all four sections to analyze how any individual student performed. Although the testing strategy remained the same, it was noted that students may get tired and bored toward the end. Finally, their suggestion of making the multimedia less linear was also good. If this lesson had been truly interactive, it would have allowed the student to investigate the topic on their own and select what they thought was interesting. Due to the constraints of the testing method, it was necessary to make sure the students using the two formats viewed the same information.

Summary

Information on Michigan's coastal dunes was gathered mostly by visits to the state parks and national lakeshores. Guided by the National Geography Standards, the content of the lesson was created. The text and accompanying graphics were placed into the two formats, traditional text and interactive multimedia. The test questions were programmed into the computer to record how long students took to answer multiple choice questions. The accuracy and response times were to be determined whether the combined information presentation types affected student learning. A small focus group, with teachers and tutors of dyslexic students as the participants, was used to evaluate the two formats and obtain suggestions for revisions. Some of these suggestions were used; others, while insightful and potentially helpful for designing future multimedia, could not be incorporated due to the constraints of the testing design.

CHAPTER 5: RESULTS, ANALYSIS AND DISCUSSION OF STUDENT TESTING

The responses from the forty-six participating students were recorded and analyzed. The results fall into four categories: the pre-test versus the sectional posttest questions, the accuracy and response times of dyslexic and non-dyslexic students to the four section posttests, attitudes toward the two formats as revealed in answers to questions posed to the student at the end of the procedure, and the students' verbal comments after completing the test.

Pretest Versus Sectional Posttests

Prior to viewing any lesson materials, the students were given a pretest to gauge their level of knowledge. The pretest served as a check on whether or not they already knew the information before proceeding through the sections. As stated in chapter 3, several easier questions were included in the pretest in an attempt to keep students from feeling discouraged. These questions were also useful in determining whether they were following directions. The easier questions were answered correctly, and thus all students were considered to be taking the testing seriously and the scores for all were used in the analysis.

By the completion of the testing, the forty-six students each answered twenty pretest questions (16 on dunes, 4 on basic geography) and thirty-two section questions (all 32 on dunes). A difference-of-proportions test was used to see if the pretest accuracy was significantly different from the accuracy on the section tests. The difference of proportions test provides a means of determining if a significant difference exists when the data are dichotomous (correct/incorrect and pretest/posttest). The resulting difference-of-proportions Z value is 3.125 and the corresponding *p*-value is0.000, indicating that number of correct responses differed significantly in the pretest versus the four section tests. Both the dyslexic and non-dyslexic students improved. The dyslexic students improved 22.3% (from 29.3% correct in the pretest to 51.6% correct in the four section tests). The non-dyslexic group improved 24.3% (from 32.4% correct in the pretest to 56.7% correct in the four section tests). The low percentages of correct answers are not surprising. The test questions were purposely made difficult in order to detect any influence of the different variables. With knowledge that students did perform significantly better after viewing the materials than they did before, the focus of the analysis can shift to investigating what aspects of the lesson helped them learn.

Accuracy and Response Times of Dyslexic and Non-dyslexic Students

The questions from the four section tests generated a large data set with 1472 entries and nine variables. The entire data set can been seen in Appendix D. The six of the nine variables that were used in analyzing the results are represented in the analysis as a single capitalized letter (denoted here in bold). The nine variables include (1) student ID # (1-46), (2) question ID # (1-40), (3) student group (dyslexic, non-dyslexic) **(S)**, (4) testing order (order in which they used the two formats, i.e., multimedia first, text second, multimedia third and text fourth, or vice versa **(T)**, (5) media type, or format, for the section in which the question appeared (multimedia, text) **(M)**, (6) number of presentation types (1, 2, 3, or 4; only the first digit in table 3.1 was used) **(P)**, (7) whether the question had been seen before in the pretest (yes, no) **(B)**, (8) accuracy of response (Y=yes, correct; N=no, incorrect) **(A)**, and (9) response times (seconds) **(R)**.

Accuracy (variable 8) and response times (variable 9) are the two dependent variables. The independent variables that were expected to have the greatest effect on accuracy and response time are the media type (variable 5) and the number of presentation types (variable 6). It was expected that the use of multimedia would improve the student's accuracy and response times, with dyslexics improving more than non-dyslexics (Figure 5.1a and b) and that dyslexics would answer almost if not just as accurately as non-dyslexics. It was also expected that the student's accuracy and response times would improve more on the questions that they had already seen in the pretest (Figure 5.1c) but the amount of improvement would be roughly equal for the two groups. While the testing order (variable 4) was not expected to alter the results, it was considered as an additional independent variable that needed to be included to assure that there were no unexpected influences caused by inadvertent differences in difficulty or quality of one set of sections over the other. For example, if the text versions of sections 1 and 3 were better than 2 and 4 and the multimedia version of section 2 and 4 were better than 1 and 3, the multimedia/text/multimedia/text group would have an unintended advantage.

Accuracy

To analyze the influence of the independent variables on accuracy, a logit log linear analysis was used. This statistical technique is used for determining the influence of categorized variables on a dichotomous dependent variable (right or wrong answers in

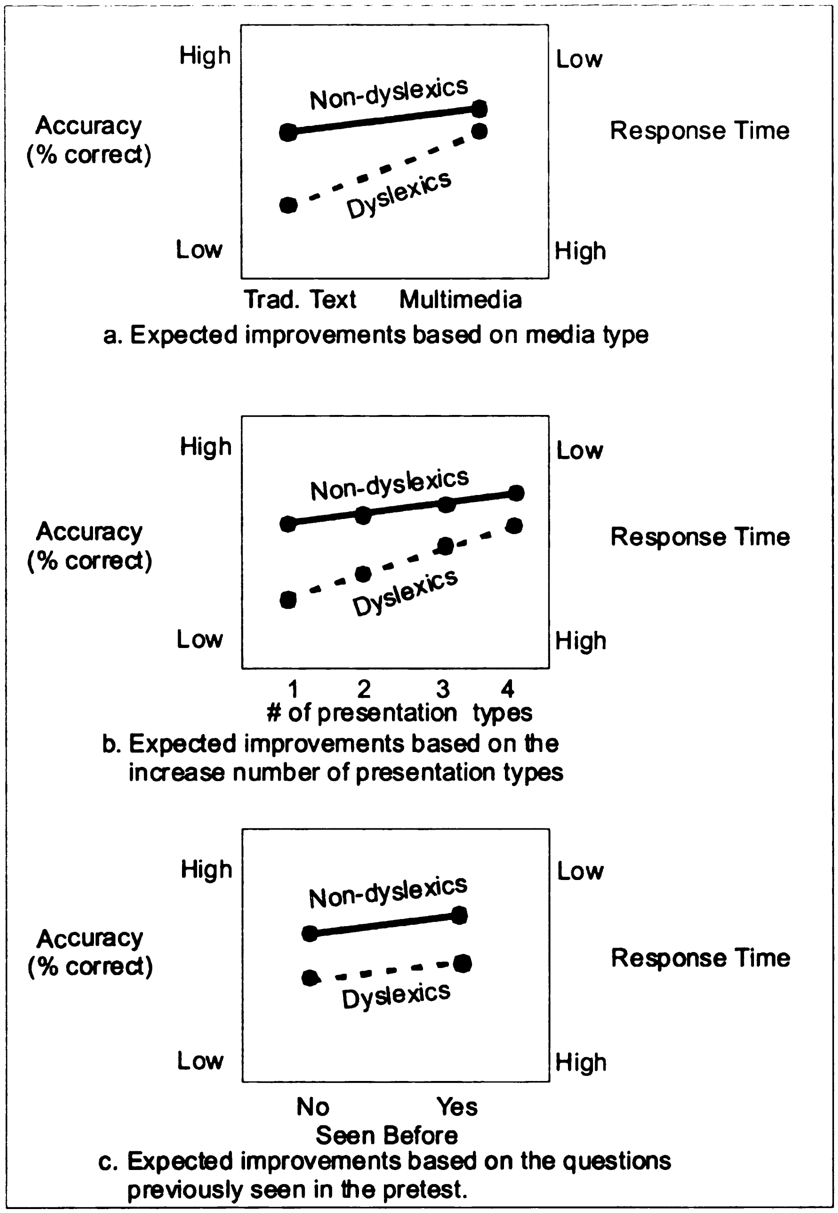


Figure 5.1: Expected improvements for dyslexic and non-dyslexic groups.

this case), and it can help determine whether one condition has a significantly different effect than another condition (Bohrnstedt and Knoke, 1994). For example, a log linear analysis can identify whether the odds of a dyslexic student having a correct answer after using interactive multimedia, with text, sound, and graphics and having seen the question during the pretest are significantly greater than the odds of the same student's answer being correct after using the traditional text version, viewing text and graphics, and not having seen the question during the pretest.

The nested nature of the logit log linear model uses the notation of the bracket, {}, with the combination of capital letters representing the variables whose interactions are hypothesized to be important plus all lower-order effects. To translate the expectations of the previous section into the notation of log-linear analysis, the expected best-fit model would be {ASM}{ASP}{AB}, or because M and P are not independent, it could be {ASM}{AB} or {ASP}{AB}.

The Bayesian information content (BIC) statistic was used to rank the models and select the best fit (Bohrnstedt and Knoke, 1994). The BIC statistic is the most negative with the best fit of variable combinations. The BIC statistic is useful for assessing logit log-linear models with large data sets, and it has been used in analyzing cartographic data (Olson and Brewer, 1997). When the number of observations is so large, ordinary significance tests often result in rejection of null hypotheses even when differences are very small. The BIC statistic separates out the model with best overall fit.

The results of the logit log-linear analysis are summarized in Table 5.1. The first model is the fully saturated one (including all interactions), followed by increasingly more simple models. The second model, for example, separated test order and accuracy from the rest of the variables. The third combination leaves out test order. The next sets of combinations include the interaction between accuracy, student group, media type, and presentation type {ASMP}; accuracy, student group, media type, and seen before {ASMB}; accuracy, student group, presentation type, and seen before {ASPB}; and accuracy, media type, presentation type, and seen before {AMPB}. The next combinations are three sets of three variables.

In Table 5.1, L^2 is the likelihood ratio chi square and *df* is the degrees of freedom. The BIC statistic is calculated as the likelihood ratio minus the degrees of freedom times the natural log of the sample size (1472). The equation is therefore BIC= L^2 -(*df*)(ln N). The lowest BIC value indicates the best fit, and, thus, {ASM}{AMP}{AB} is the best model. That means that the interaction between accuracy, student group, and media type; between accuracy, media type, and number of presentation types; and between accuracy and seen before are most important.

The results of the BIC statistic were not altogether surprising but showed an interesting unexpected interaction. It was expected that there would be an interaction between accuracy, student group and media type, and/or between accuracy, student group, and number of presentation types. The explicit appearance in the model of interaction among accuracy, media type, and presentation types is a logical outcome simply overlooked in anticipating outcomes. The resulting model supports the expectations but reminds us that the number of presentation types differs for the two media formats; multimedia has more presentation types than text.

To examine the results of the log-linear analysis, Table 5.2 lists the odds of a correct answer by component, in the {ASM}{AMP}{AB} model. In this table, the coefficients for variables in the model are listed. The coefficients with higher absolute values have the stronger effects on accuracy. The table also lists the associated Z

Combinations	L^2	df	ln N	(df)(lnN)	BIC
{ASMPBT}	0.00	0.00	7.29	0.00	0.00
{ASMPB}{AT}	1527.20	118.00	7.29	860.69	666.51
{ASMPB}	0.00	0.00	7.29	0.00	0.00
{ASMP}	781.32	25.00	7.29	182.35	598.97
{ASMB}	91.18	11.00	7.29	80.23	10.95
{ASPB}	359.54	25.00	7.29	182.35	177.19
{AMPB}	958.86	25.00	7.29	182.35	776.51
{ASP}{APB}{ASB}	0.88	6.00	7.29	43.76	-42.88
{ASM}{ASP}{ASB}	124.65	6.00	7.29	43.76	80.89
{ASP}{ASB}{AMP}	78.96	14.00	7.29	102.12	-23.16
{AMP}{AMB}{APB}	109.01	14.00	7.29	102.12	6.89
{ASM}{ASP}{AB}	162.83	14.00	7.29	102.12	60.71
{ASM}{AMP}{AB}	**209.00**	**42.00**	**7.29**	**306.35**	**-97.35**
{AMP}{AS}{AB}	318.46	42.00	7.29	306.35	12.11
{AMP}{AMB}	145.97	12.00	7.29	87.53	58.44
{AMP}{APB}	85.73	8.00	7.29	58.35	27.38
{ASM}{AMP}	12.34	12.00	7.29	87.53	-75.19
{ASM}{AMB}	1.35	4.00	7.29	29.18	-27.83
{ASM}{ASP}	492.79	12.00	7.29	87.53	405.26
{ASP}{AB}	110.70	14.00	7.29	102.12	8.58
{ASP}{AM}	497.13	14.00	7.29	102.12	395.01
{ASM}{AB}	47.95	6.00	7.29	43.76	4.19
{ASM}	41.50	4.00	7.29	29.18	12.32
{ASP}	247.11	10.00	7.29	72.94	174.17
{ASB}	2.69	4.00	7.29	29.18	-26.49
{AMP}	764.56	10.00	7.29	72.94	691.62
{AMB}	85.41	4.00	7.29	29.18	56.23
{APB}	341.37	10.00	7.29	72.94	268.43
{AS}{AM}{AP}	511.39	20.00	7.29	145.88	365.51
{AS}{AM}{AB}	52.30	8.00	7.29	58.35	-6.05
{AS}{AP}{AB}	124.94	20.00	7.29	145.88	-20.94
{AM}{AP}{AB}	687.25	20.00	7.29	145.88	541.37
[AS}{AM}	4.35	2.00	7.29	14.59	-10.24
[AS}{AP}	14.24	6.00	7.29	43.76	-29.52
[AS}{AB}	0.89	2.00	7.29	14.59	-13.70
[AM}{AP}	494.68	6.00	7.29	43.76	450.92
[AM}{AB}	46.60	2.00	7.29	14.59	32.01
{AP}AB}	106.84	6.00	7.29	43.76	63.08
{AS}	0.07	1.00	7.29	7.29	-7.22
{AM}	37.08	1.00	7.29	7.29	29.79
{AP}	232.80	3.00	7.29	21.88	210.92
{AB}	1.73	1.00	7.29	7.29	-5.57

Sample Size N=1472
Dependent dichotomous variable-A, accuracy (right, wrong)
Independent variables-S, student group (dyslexic, non-dyslexic)
M, media type (multimedia, traditional text)
P, number of presentation type (1, 2, 3, 4)
B, seen before (yes, no)
T, test version (1, 2)

Table 5.1: Results from the logit log-linear analysis on student accuracy

scores, which measure the significance. Those listed in bold text are significant at the 0.05 level and have absolute Z-scores greater than 1.96.

The first line of Table 5.2 shows that there were less correct than incorrect responses, or more precisely, an odds ratio of 0.82:1 of being correct. As stated previously, the test had to be difficult in order to detect any differences in the influence of different variables. The second group, {AS}, compares a dyslexic student's odds (0.80:1) to a non-dyslexic student's odds (0.83:1) of responding to questions accurately. Next, we see the odds for {AM}, accuracy and media type. The odds of a student getting the answer correct in the text format are 0.54:1 and 1.13:1 in the multimedia format.

The next set {ASM} looks at the odds of a correct answer for dyslexic and non-dyslexic students using the text versus the multimedia format. Both groups of students increase in odds of responding correctly to questions for which answers came from information gained from the multimedia format over the text format. Dyslexic students increase from 0.52:1 to 1.04:1 and non-dyslexic students increase from 0.60:1 to 1.11:1. While the increase is relatively close for the two groups of students (a 0.52 increase for dyslexic students and a 0.51 increase for non-dyslexic students), the interaction term is significant (dyslexics did improve slightly more and the effect is statistically significant). Also, the odds ratio suggests a more important effect for the dyslexic students. The odds ratio for dyslexic students is 1.04 /0.52 or 2.00, and for non-dyslexic students it is 1.11/0.51 or 1.85. This difference suggests that dyslexic students had greater relative improvement.

The next set of odds looks at {AP}, accuracy and presentation type. While only two, three, and four presentation types are significant, there is a definite trend in the increasing odds of getting an answer correct: 0.85:1, 2.55:1 and 44.00:1 respectively. The following set examines the odds of a correct answer by media type and presentation types, {AMP}. In this set, only three and four presentation types are significant. In both the two and three presentation types, the odds of getting the answer correct are greater for the multimedia format than for text format for any given number of presentation types (0.92:1 vs. 0.81:1 for two presentation types and 2.58:1 vs. 0.00:1 for three presentation types). It is important to note that while the odds for three presentations are significant,

Model Terms	***Coefficient***	***Z-Score***	***Odds***
{A} Accuracy			
Correct/incorrect	-1.96	**-3.75**	0.82
{AS} Accuracy and Student Group			
Dyslexic	0.63	**2.69**	0.80
Non-dyslexics	0.76	**2.79**	0.83
{AM} Accuracy and Media Type			
using text	-0.77	**-4.56**	0.54
using multimedia	-0.89	**-4.78**	1.13
{ASM} Accuracy, Student Group, and Media Type			
Dyslexic using text	0.01	**2.26**	0.52
Dyslexic using multimedia	0.01	**2.28**	1.04
Non-dyslexics using text	0.04	**2.24**	0.60
Non-dyslexics using multimedia	0.06	**2.30**	1.11
{AP} Accuracy and Number of Presentation Types			
1 presentation type	-0.12	0.30	0.36
2 presentation types	-0.01	0.31	0.85
3 presentation types	0.24	**2.41**	2.55
4 presentation types	0.98	**4.76**	44.00
{AMP} Accuracy, Media Type, and Number of Presentation Types			
using text and 1 presentation type	-0.21	-0.17	0.42
using multimedia and 1 presentation type	0.11	0.12	0.24
using text and 2 presentation types	0.01	0.24	0.81
using multimedia and 2 presentation types	0.01	0.35	0.92
using text and 3 presentation types	0.00	**4.76**	0.00
using multimedia and 3 presentation types	0.84	**8.88**	2.58
using text and 4 presentation types	-------	------	-----
using multimedia and 4 presentation types	0.98	**17.45**	44.00
{AB} Accuracy and Seen Before			
yes	0.88	**13.98**	0.88
no	0.67	**12.73**	0.77

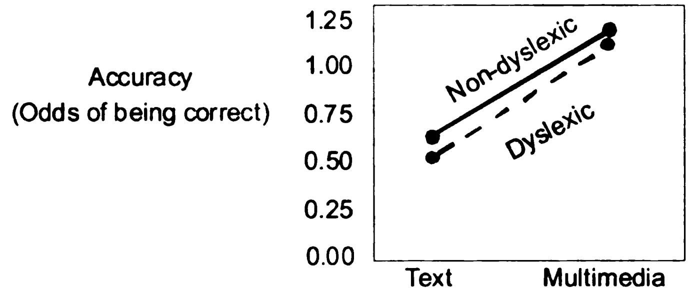
Table 5.2: Detailed examination of the logit log linear analysis {ASM} {AMP} {AB}.

there was only one question in the text format that used three presentation types. The odds for four presentation types are the same as in the {AP} section because of the nature of the two formats. The text format did not contain four presentation types for any question.

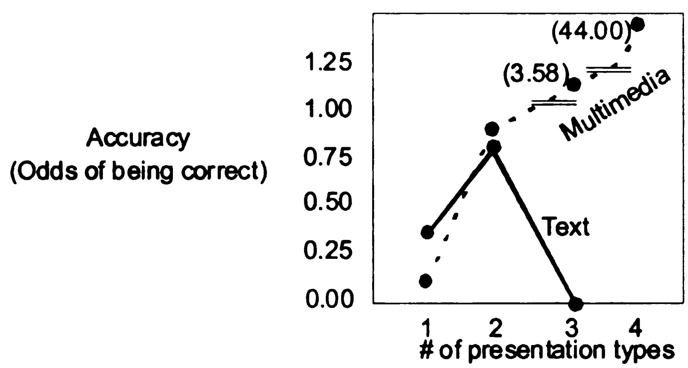
The next set of odds compares correct answers and whether or not the student had seen the question in the pretest. The results indicate that students have a significantly better chance of answering the question correctly if they had seen the question before. The odds decrease from a 0.88:1 ratio if they had, to a 0.77:1 ratio if they had not seen the question before. Figure 5.2 displays the accuracy odds for the best fit model.

Response Time

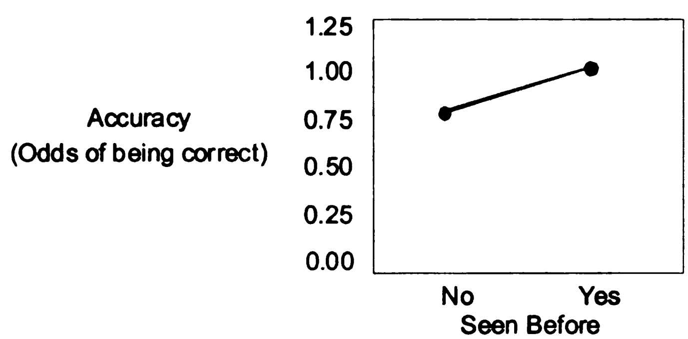
The time it took students to respond to each question in the four section tests was recorded in seconds. Times ranged from one second to 57 seconds. The response time is a quantitative measure rather than a categorical one, and thus an analysis of variance (ANOVA) was used to analyze the data. The ANOVA used times for correct responses only. Table 5.3 lists the individual variables along with the two-way, three-way, four-way, and even five-way interactions, and the F-value, degrees of freedom (*df*), and the probability (p) for each. The variable(s) that have a significant effect on reaction time, within the 0.05 significance level, are in bold.



a. Observed improvements between student group and media type {ASM}



b. Observed improvements between media type and number of presentations {AMP}



c. Observed improvements between questions previously seen in the pretest {AB}

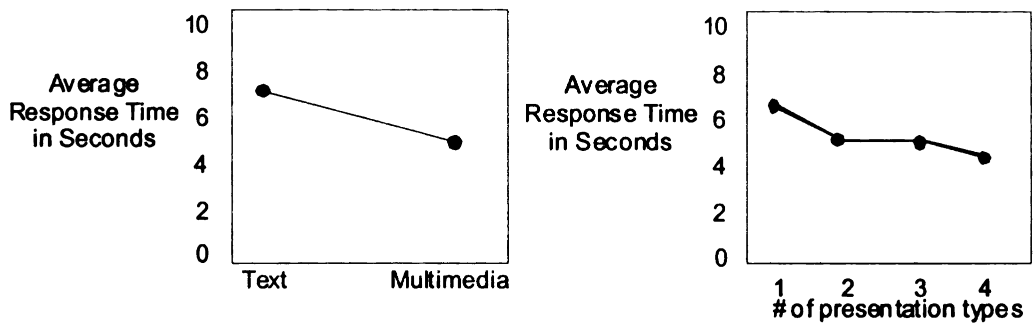
Figure 5.2 Observed accuracy odds for the best fit model {ASM} {AMP} {AB}

Variables	F	*df*	p
M	**6.88**	**1**	**0.01**
S	0.47	1	0.32
B	0.22	1	0.61
P	**8.78**	**3**	**0.00**
M * S	**10.45**	**1**	**0.00**
M * B	**6.01**	**1**	**0.01**
S * B	1.99	1	0.19
M * S * B	**12.34**	**1**	**0.00**
M * P	**2.56**	**2**	**0.01**
S * P	2.22	3	0.09
M * S * P	1.10	1	0.67
B * P	**4.56**	**3**	**0.01**
M * B * P	1.65	1	0.23
S * B * P	3.46	3	0.09
M * S * B * P	2.48	1	0.14

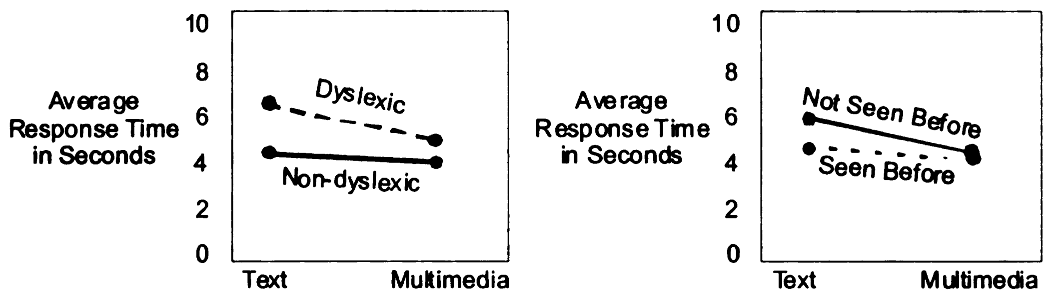
Sample Size N=664
Variables-
S, student group (dyslexic, non-dyslexic)
M, media type (multimedia, traditional text)
P, number of presentation types (1, 2, 3, 4)
B, seen before (yes, no)

Table 5.3: ANOVA results on variables influencing response times. Those variables and their interactions that significantly affect the response time in the four section tests are highlighted.

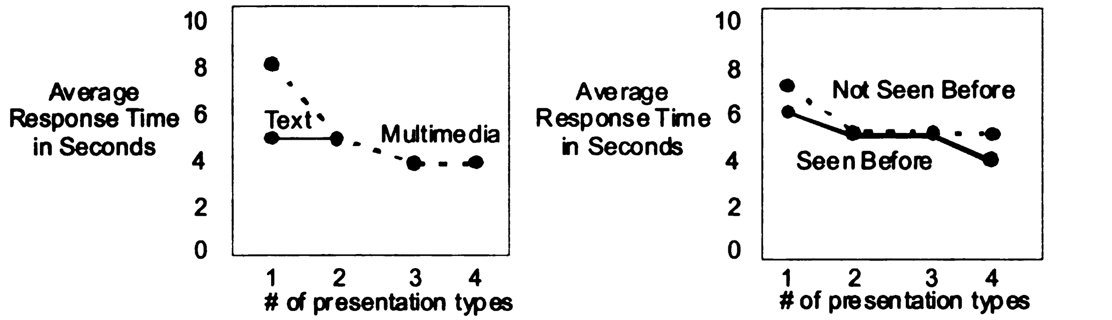
Figure 5.3 displays the average observed response times for significant variables and interactions. Media type and presentation type as individual variables affect reaction time, and media type appears in two-way interactions with student group, seen before, and presentation types. Seen before and presentation types is another significant two-way interaction. Media type, student group, and seen before is the significant three-way interaction. Text with only 1 and 2 presentation types among the questions answered correctly, shows no improvement with the greater number of types, whereas multimedia does (Figure 5.3c). Seen before shows overall lower reaction times but noticeably lower times for 1 and 4 presentation types (Figure 5.3c). Except for non-dyslexic, seen before, response times for the two student groups are lower for multimedia and drop more for not seen before than for seen before (the three-way interaction in Figure 5.3d). Apparently seeing the question on the pretest primes the subject and takes away some of the differences between text and multimedia. It was expected that response time would be influenced by student group, media type, number of presentation types, and whether the student had seen the question before. It was not surprising that response time would be influenced by a combination of these variables.



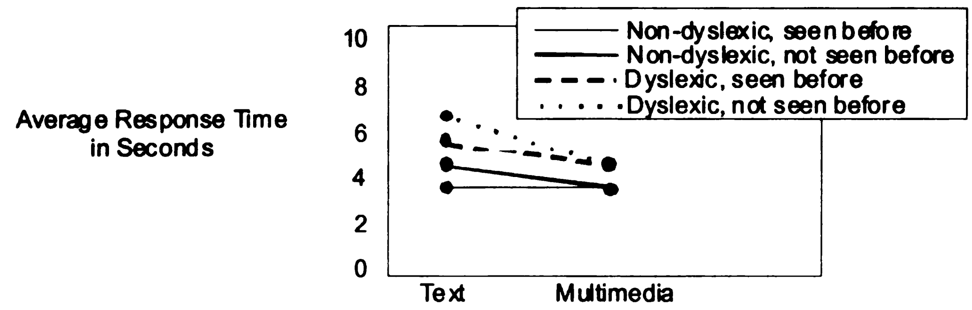
a. Observed response times of single variables: media type and number of presentation types



b. Observed response times with two interacting variables: media type and student group and media type and seen before



c. Observed response times with two interacting variables: media type and the number of presentation types and seen before and number of presentations



d. Observed response times between three variables: media type, student group, and seen before

Figure 5.3: Observed average response times associated with significant variables from the ANOVA

Attitude Questions

After the students completed all four sections of the geographic lesson and the multiple choice questions, they were asked eight attitude questions. In this segment, the student saw the same question stem, "Which do you find the most...", but in each case the adjective changed. The following tables list the results for both dyslexic and non-dyslexic students.

1.Which do you find the most **Interesting?**

	Dyslexic	Non-Dyslexic
Text	0	1
Multimedia	20	19
Both	2	2
Neither	2	0

2. Which do you find the most **Fun?**

	Dyslexic	Non-Dyslexic
Text	0	0
Multimedia	22	21
Both	1	0
Neither	1	1

3. Which do you find the most **Difficult?**

	Dyslexic	Non-Dyslexic
Text	15	6
Multimedia	0	0
Both	4	0
Neither	5	16

4. Which do you find the most **Confusing?**

	Dyslexic	Non-Dyslexic
Text	14	4
Multimedia	0	0
Both	0	0
Neither	10	18

5. Which do you find the most **Boring?**

	Dyslexic	Non-Dyslexic
Text	19	16
Multimedia	0	0
Both	0	1
Neither	5	5

6. Which do you find the most **Cool?**

	Dyslexic	Non-Dyslexic
Text	0	0
Multimedia	22	20
Both	2	1
Neither	0	1

7. Which do you find the most **Truthful?**

	Dyslexic	Non-Dyslexic
Text	0	0
Multimedia	6	4
Both	18	17
Neither	0	1

After completing the testing, it was noted that the third and fourth options are technically the same. While the two options have different connotations, if *both* formats are "..the most..." then *neither* is "...the most...", and thus those answers were considered the same in the analysis. The students' attitudes are evident, without performing significance tests. Almost every student found the multimedia sections of the lesson to be more interesting, fun, and cool, while most students found the text sections to be boring. No students found the multimedia sections to be the most boring. Likewise, no students found the text to be the most fun or to be the most cool. Only one student found the text format to be more interesting.

A discrepancy between the attitudes of dyslexic and non-dyslexic students arose on the questions on which format they found the most difficult and confusing. Sixty percent of the dyslexic students found the text formats to be more difficult. The remaining forty percent was split relatively equally among finding both most difficult and finding neither most difficult which suggests the wording problem led them to choose randomly between the two answers. However, 71 percent of non-dyslexic students found neither format most difficult. No one answered "multimedia" as the more difficult of the two formats. A similar pattern emerges with the attitude question of which format they found to be the most confusing. Sixty-six percent of the dyslexic students found the text formats to be confusing, whereas the remaining forty percent found neither to be confusing. Eighty percent of the non-dyslexic students, on the other hand, found neither format "most confusing". Again, no one answered "multimedia" as the more confusing of the two formats.

The majority of both dyslexic and non-dyslexic students (76% for both groups) answered that they found both formats truthful. The remaining students answered that they found the multimedia sections more truthful. No student found the text formats to be more truthful. Since both formats contained the same information, it is interesting that some students might question the truthfulness of written text but not of a computer presentation.

The student responses to the attitude questions can be used to answer the question of preference and overall enthusiasm for the two formats. The answers to the questions clearly show that both dyslexic and non-dyslexic students are more favorably inclined toward interactive multimedia than text format. The Difficult and Confusing items show that while a large number of dyslexics find a multisensory format less difficult, some non-dyslexic students also found it so. These responses support the original expectations.

Student Comments on Testing Materials

After the students answered all the questions given on the computer, I asked them open-ended questions (see follow-up questions in Appendix B) and allowed them to give any comments or criticisms they wished to offer about either format or the test. Given the age of the participants I was not surprised to get mostly shoulder shrugs and nods of approval. The dyslexic students gave more feedback than non-dyslexics. They have undergone more testing than the non-dyslexic students, and are more accustomed to discussing their learning preferences.

Overall, most students making comments said they liked participating in the study, and they liked learning about dunes. Several students commented on the timing (this experiment was done near the end of the school year) and said they wanted to visit the dunes during the summer. Many of the students told me about summer vacation plans which included camping, hiking, and boating near the dunes.

One of the criticisms that arose about participating in the study was the length of time. Several students said that it was too long and that they were getting tired by the end of the four sections. The focus group had commented that the length of time and the amount of information might be too much for some students. Figure 5.2 charts the number of correct answers per lesson section. Indeed, the percent correct decreases in the third and fourth sections compared to the first and second sections; however, the third and fourth remain approximately the same (43% and 42% respectively for dyslexics and 49% and 48% for non-dyslexics). It is quite possible, however, that the last two lessons were harder. The experiment would have had to present each section equally in each slot in the time sequence to separate clearly the effects of fatigue.

Most of the students said that they liked learning on the computer better. They said they liked the pictures and maps, and they liked being able to move at their own speed. Many of the dyslexic students noted that they are visual learners and thus the graphics helped them learn. It is amusing to have eighth grade students say that they are "visual learners", and granted a teacher, parent, or tutor has probably told them that; but it still seems that they have a preference and can identify how they like to learn. The accuracy results suggest that using multiple presentation types increases learning. While multiple presentation types can be incorporated into both formats, multimedia lends itself better to incorporating three or four media types, and graphical information in particular is easier to include for those who are visual learners.

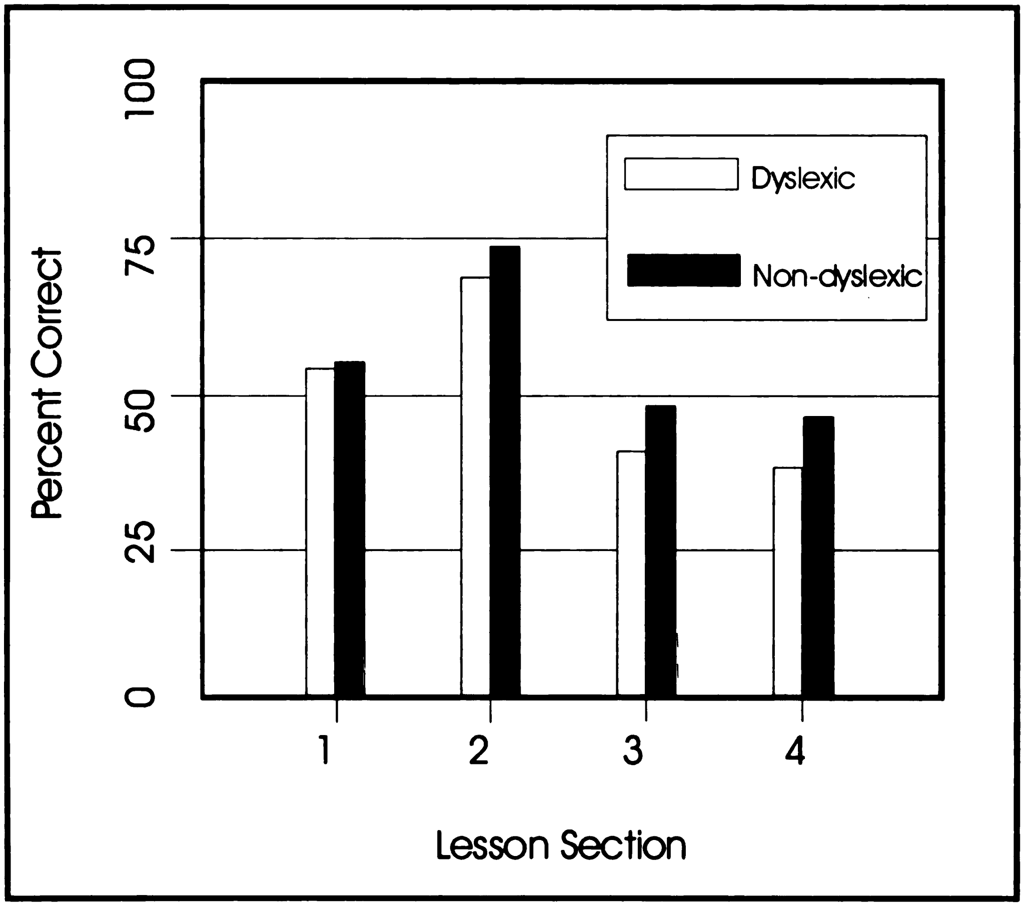


Figure 5.4: Histogram of dyslexic and non-dyslexic accuracy performance per lesson section.

Several students commented on the computer reading several of the text passages, and many students wished the computer read all of it aloud. One dyslexic student even stopped during the first section to say the program wasn't working. He had heard the computer read the first text passage and assumed the program stopped working when it didn't read the second one. He was disappointed when he was informed that he had to read on his own. All dyslexic students stated that they appreciated the test questions read to them. Many commented on their difficulty with tests and believed that this really helped them.

When asked how the geographic lesson could be improved, many of the students said skip the text formats and do all sections on the computer. A few students said that it might be more interesting if it were turned into a game. One boy suggested having a dune treasure hunt with clues that could be solved only if you knew the information from the previous screens. While this sounds like one of the well-known interactive programs, *Where in the World is Carmen San Diego*, it is a sound pedagogical approach to immediately question what the student has learned.

A few additional comments were recorded during and after the testing sessions that should be noted. First, the body language of the students suggested they were more distracted during the traditional text format sections. Many of the students would rock back in their chairs, lay their heads on the desk, and look around the room while proceeding through the text formats. One student even asked to leave to go to the bathroom. During the multimedia sections the students seemed to be more attentive, sat up straight in their chairs and had to keep looking at the computer screen. By having to continually click with the mouse, it forced the students to take a more physically active approach.

Second, appreciation was expressed by dyslexic students and their parents. I thanked every student for participating in the study, and every dyslexic student thanked me for conducting it. One dyslexic girl said that she finds school frustrating and she's been asking her parents for home-schooling. She thought that if there were more programs such as this one, her parents would agree to teach her at home. Many parents of the dyslexic students made a special trip to come and pick up their child and to personally thank me for working on this topic. I was surprised at the willingness and eagerness of the parents of the dyslexic students to help me collect the data.

In summary, the open-ended questions and additional comments I received from students certainly reinforced the interactive multimedia preference reported in the attitude questions. There was a strong preference for the interactive multimedia by both dyslexic and non-dyslexic students. While both types of students were more enthusiastic about the computer, the dyslexic students stressed that it was easier to learn, and they were appreciative of potential new tools for their learning.

Discussion

The results of this experiment can now help to answer the initial five questions posed in Chapter 3. The results indicate that interactive multimedia, with its ability to incorporate multisensory learning pathways, helps dyslexic and non-dyslexic students in terms of accuracy, response times, and enthusiasm.

The results of the logit log-linear analysis helps to answer two of the initial five questions posed at the onset of this study. The two questions focused on whether or not interactive multimedia and the increase in the number of presentation types would help dyslexic and non-dyslexic students recall information accurately. While it was expected that multimedia and an increased number of presentation types would have a positive effect on dyslexic students, it was expected to have little or no effect on non-dyslexic students.

The best-fit model in the log-linear analysis indicated an interaction among accuracy, student groups (dyslexic/non-dyslexic), and media type (multimedia/text), and between accuracy, student group, and the number of presentation types (1, 2, 3, or 4). The detailed examination of the best-fit model revealed significant odds of a student answering a question correctly under given conditions. When comparing only media type, all students have better odds of answering questions correctly when using the multimedia format. Although the interaction between student group and media type was significant (i.e., the improvement was not quite parallel), the coefficient, or the strength of the interaction, was slight. On the other hand, if we look at the odds ratios for the two groups (2.00 for dyslexics and 1.85 for non-dyslexics) the dyslexic students did improve with a greater ratio. The expectation of non-dyslexic students not improving, or not improving as much, was only weakly supported.

The higher accuracy by the students when using multimedia is interesting because it is a different result from many of the studies previously mentioned in Chapter 2. Many studies show that students are enthusiastic about learning on the computer, but they do not actually perform significantly better than with traditional methods. However, it is not unrealistic to expect students to learn more if they are more interested in learning. During the testing period it was evident that students were more engaged with the sections completed on the computer versus those completed in the text format. The large number of questions answered may have allowed the achievement of significance in this study. On the other hand, the use of the BIC statistic assures that only the most important variables remain in the model. Also, the overall percent correct for the text sections was

37.19% and the for multimedia 52.93% which is surely significant educationally as well as statistically.

The interaction between accuracy and the number of presentation types, and accuracy, media type, and number of presentation types also appeared in the best-fit logit log-linear model. These results indicate that an increased number of presentation types increased the odds of a student answering a question correctly, but the number of questions with three or four presentation types in the text format is extremely limited (one and zero, respectively), causing the {AMP} interaction to appear in the model.

One of the implicit goals of this study was to assess whether multimedia could potentially help dyslexic students learn and perform just as well as non-dyslexic students. The results indicate that there still remains the discrepancy gap with dyslexic students performing less well than non-dyslexic students and that both sets of students learned more using the multimedia format than they did using the text format.

The results of the ANOVA help to answer two of the initial five questions posed at the onset of this study that pertain to response times. It was expected that information learned from multimedia and/or an increased number of presentation types would help dyslexic students respond to questions more quickly than information learned in a text format with fewer numbers of presentation types. Again, little or no difference was expected amongst response times of non-dyslexic students.

The ANOVA indicated that response times were influenced by media type and number of presentation types, along with a variety of combined interactions. The multimedia format and the increased number of presentation types decreased the response times for both dyslexic and non-dyslexic students (7.89 seconds with 1 presentation type vs. 4.01 seconds with 4 presentation types). The average response times with text were 6.42 for dyslexic students and 4.78 for non-dyslexics, 5.01 and 4.09 respectively with the multimedia format. While a gap still exists between dyslexic and non-dyslexic students' response times, the dyslexic students have a greater decrease in average response times (1.67 vs. 1.41).

The on-screen attitude tests and the post-testing interview helped answer the fifth and final question posed at the beginning of the study: Do students prefer or express enthusiasm for one format over another. The answer here is overwhelmingly "yes." In both the onscreen adjective questions and the open-ended questions at the end, the students preferred to learn using the interactive multimedia. As expected, the dyslexic students reported more often that traditional text gave them problems than did the non-dyslexic students, as indicated in reactions to the "difficult" and "confusing" adjectives, but both groups found the interactive multimedia to be more "interesting", "fun", and "cool."

Summary

The results of this experiment were analyzed in four parts. First, the pretest versus the post section tests indicated that students did indeed learn something from the geography lesson. Once this was established, analysis of the effects of the variables could proceed.

The accuracy and response time results from the four sections showed an interaction between media type and the number of presentation types by which a student receives information, along with whether or not they had seen the question before. Both dyslexic and non-dyslexic students answered with greater accuracy when using the multimedia format rather than the text format. They also showed greater accuracy when they learned with an increased number of presentation types. With more than two presentation types, a trend of significant odds indicates that while keeping the number of presentation types constant, both groups of students were more accurate with the multimedia format than they were with the text format. The multimedia and the increased number of presentation types also proved to be important variables for improving response times. Although the students with dyslexia still do not perform at the same level as the non-dyslexic students, as originally hoped for, they have a significant learning improvement.

The third and fourth part of the analysis focused on student learning preferences. Both the student comments completed on the computer and the open-ended questions and comments were overwhelmingly in favor of learning by interactive multimedia. The dyslexic students found the interactive multimedia less frustrating than the traditional text and particularly seemed to like the addition of sound. While the non-dyslexic students did not find the text frustrating, they expressed more enthusiasm for learning with the interactive multimedia. In conclusion, the results from this study suggest that multimedia, and the increase in the number of presentation types that can easily be included in an interactive multimedia module, will improve both dyslexic and non-dyslexic students' accuracy and response time while increasing their enthusiasm for the mode of presentation.

CHAPTER 6: REFLECTIONS ON THE EXPERIMENT AND CONCLUSIONS

In this study I attempted to assess the usefulness of multimedia as an educational tool for presenting geographic material to dyslexic and non-dyslexic eighth grade students. As with any experiment there are elements that could have been improved. It is important to reflect on the methods used to conduct this experiment and assess how possible variations may have altered the results and how future testing could be better. After discussing these matters, the significance of this research, flawless or not, and a summary of its place in current cartography will be presented.

Testing Considerations

One variation on the study could have been the lesson content. The geographic lesson was created with eighth grade students and the geographic standards in mind. The topic of dunes was chosen because it was believed to be a topic that would interest most eighth graders but about which most would not have learned in a formal setting. Of the four sections, it was evident that the students were most interested in the animals and environmental issues (section 3 and 4). One student suggested creating a lesson on dinosaurs, and another student suggested creating a lesson on astronomy. Obviously, the more student-oriented the topic the more enthusiasm would be created for the lesson, although what students <u>want</u> to learn and what they <u>should</u> learn is not always the same. Whether more enthusiasm would have affected the test results, however, is questionable. It is conceivable, but not necessarily probable, that it would have led to more uniform scores across groups. That possibility does seem more likely than an increased differentiation, and from an experimental point of view, we need to be working where the differences are the most likely to be observed.

A second variation in the methods that may affect the results is the time required of the students. The length of the test may have been too long for a one-day session. The teachers and tutors in the focus group evaluation warned that the four sections would be a lot of material for one session. They also suggested that some students may become restless and distracted toward the end, and several students commented on the length. A possible alternative for future studies may be to have students complete one section a day, or have one student complete only one section in each format, although that is a weaker research design.

Third, a stronger research design would involve paired comparisons in which each individual participant answers the same question or one directly comparable after using each version of the material. Such a design is extremely difficult to devise but would be far more powerful in detecting any differences between the groups in the amount of improvement using one medium over the other.

A fourth consideration of the methodology that should be addressed is the structured nature of the test. Interactive multimedia should be exploratory; students should presumably direct their learning based on their personal interests and lines of thinking. In order to compare test scores between formats, the interactive multimedia sections had to be fairly linear to ensure that students viewed the same information. How to truly test the effectiveness of the multimedia format is an open issue.

Conclusions and Significance

The results of this experiment helped to answer the initial five questions posed in Chapter 3. Equally important, however, is that this study fits within a body of literature, and its results can be generalized to broaden the knowledge of interactive multimedia for geographic education as well as add to the growing interest in geography for, and by, disabled populations.

The results indicate that interactive multimedia with its incorporation of multisensory learning possibilities helps dyslexic and non-dyslexic students in terms of accuracy, response times, and enthusiasm. Unquestionably, the number of presentation types affects all students' accuracy and response times. Even though the numbers of questions allowing for comparison of the same number of presentation types between formats is limited, and thus may be of concern, multimedia positively influenced accuracy and response times. In addition, the inherent nature of multimedia lends it to easier incorporation of information in more presentation types than does the traditional text format.

The results were conclusive on student learning preferences and attitudes about interactive multimedia. As in many other studies, students overwhelmingly preferred to learn on the computer using interactive multimedia for this lesson. While the education system's goal is not strictly to be "fun," if students are enthusiastic about the media they are using to learn, they may be more willing and eager to learn. Geography, with its disciplinary roots in explaining spatial patterns and processes, is an ideal subject to be taught with interactive multimedia.

The results of this experiment identified learning benefits of utilizing multiple presentation types, which can easily be incorporated into interactive multimedia to help students learn important geographic concepts. It was found particularly useful for dyslexic students to gain information with less frustration. These results are not only beneficial to those dyslexic students who participated in this study, but to all dyslexic students who are eager to learn, to their teachers, and to society at large. Further investigation into interactive multimedia and multiple presentation types, such as text, graphics, and sound to teach important geographic concepts could aid in future developments for students with other learning disabilities as well. Although this study focused on dyslexics, it is important to remember that all students learned more with multiple presentation types and preferred learning on the computer. On a more general level, therefore, this study contributes to the growing interest and knowledge of the effectiveness and potential contributions of interactive multimedia as tools in geography education.

In conclusion, the fundamental themes and concepts in this research are a product of current trends in cartography. The maps in this study were embedded within a geography lesson based on the current geography education standards, and the study was aimed at assisting a population group, dyslexics, that society now understands as simply having difficulty with a particular learning mode. On the technological side, the study used multimedia, a tool that has become routine in in mapping at this stage in cartographic history. As a product of current societal and technological trends, then, the study has the potential to be outdated as those trends change. On the other hand, the need to understand how people read and gain information from maps is both timely and timeless. Further understanding of dyslexia may refine our approach to helping dyslexics learn, but it is unlikely that numbers of presentation types, for example, will cease to have an influence on both dyslexics and non-dyslexics. The form of multimedia used in the study is already becoming quaint as virtual reality and Internet multimedia with their far greatly flexibility are taking over. But those changes will simply make it all the more possible to incorporate ways to help students learn.

As this project started, its distinction from other multimedia effectiveness studies was its emphasis on maps and improved learning of geography by dyslexics. What has emerged is a clearer idea of what helps everyone learn.

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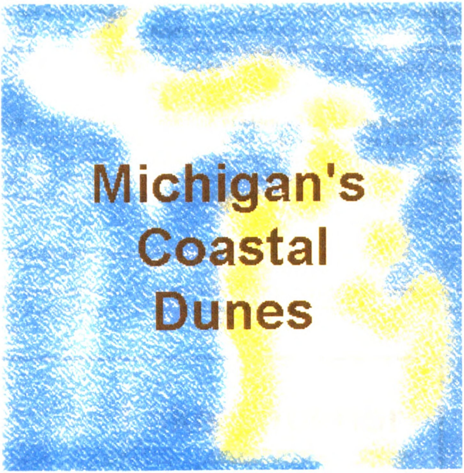
APPENDIX A

Section 1:
Location of Michigan's Coastal Dunes



Section 1: Dune Locations

1. Introduction
2. Characteristics of Dunes on different coasts
3. Location of Specific dunes

Introduction

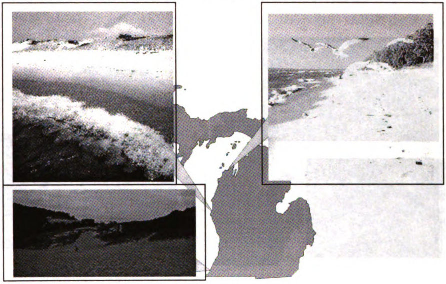
The location of the Great Lakes relative to the state of Michigan gives the state a unique physical and cultural geography. It is reflected in the state's motto "If you seek a pleasant peninsula then look around you." A peninsula is a relatively narrow piece of land extending out into a body of water. The lakes provide a means of transportation, support a vital fishing industry, balance a diverse flora and fauna ecosystem, and provide scenic areas for recreation purposes. With so many opportunities, you can see why the Michigan Tourism Association changed its slogan in 1998 to "Great Lakes. Great Times."

With over 3,200 miles of coastline, of which a good portion is sandy, Michigan contains the largest expanse of freshwater dunes in the world. Over 1,000 miles of these dunes are public beaches. The dunes are often the main feature in many of Michigan's 96 State Parks and in Michigan's two National Lakeshores. The Parks and Lakeshores are open year round and are great places to study and enjoy the dunes.

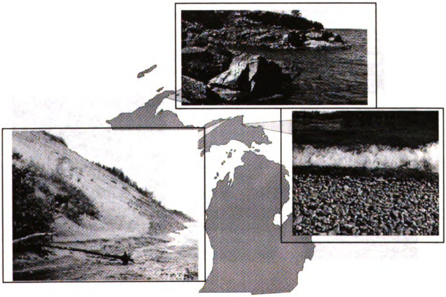
Characteristics of Dunes on Different Coasts

The dunes on the Michigan shoreline differ from place to place because of differences in prevailing winds and availability of sand. Lets look at some of these differences.

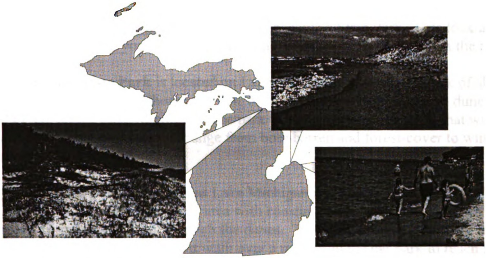
1. The dunes found along **Lake Michigan's** shoreline tend to consist of soft, white sand. Of the four Great Lakes, Michigan, Huron, Superior, and Erie, Lake Michigan has the most abundant sand and dunes that extend for miles and often rise hundreds of feet above the shoreline. In fact, Michigan's western Lower Peninsula is the longest freshwater beach in the world, extending for 200 miles. Fourteen State Parks, dedicated to protecting Michigan's coastal dunes, are located along Lake Michigan's shores. Here are three photographs from along this coast. Notice the abundance of sand.



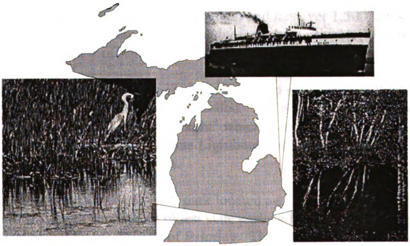
2.Lake Superior is the largest freshwater body in the world; however, it does not have as many sandy beaches as Lake Michigan. Much of the coastline is wilderness with steep rock cliffs and forested shores. Here are three photographs of Michigan's Lake Superior shoreline.



3. The **Lake Huron** shoreline ranges from rocky coasts to sandy beaches. Here the dunes have a much lower relief than those along the Lake Michigan shoreline. In addition, the dunes do not stretch for any great length. The four State Parks on Lake Huron extend for only a mile or two. This is much shorter then the coastlines of the State Parks on Lake Michigan that have 10, 15, and even 35 miles of sandy beaches. In the three photographs of Lake Huron beaches, notice the combination of sand and rocky shorelines.



4. **Lake Erie** is the Great Lake most used for transportation and it is home to many boaters and fishermen. It does not however contain many sandy deposits that form dunes. Most of Michigan's border with Lake Erie consists of marshes and bogs. Although it may not attract those seeking high dune bluffs and long stretches of beach, it does attract many bird watchers and hunters. These three photographs characterize much of Michigan's Lake Erie shoreline.



Location of Specific Dunes

Michigan has almost 100 state parks and two national lakeshores. All of Michigan's Parks aim to preserve the state's natural features and historical sites. The parks preserve inland waterways, waterfalls, old-growth forest, and particularly freshwater coastal sand dunes.

Twenty of Michigan's State Parks are devoted to protecting coastal sand dunes. You can see where these twenty are located on the Coastal Dunes map. All of these parks have a unique setting or history of how and why the land became a State Park. Lets look at a few of these parks. When you read about each one, find where it is located on the map.

A. **Warren Dunes State Park** is located on Lake Michigan. It is a large park of about 2,000 acres and 2 miles of shoreline. One of its spectacular features is the dune that rise 240 feet above Lake Michigan. The park offers several nature trails that wind between dune environments that range from both barren and forest-cover to winding streams and wildflowers.

B. **Saugatuck State Park** is located on Lake Michigan and has about 300 acres of land, much of which is preserved natural area with coastal dunes. The park offers an extensive 14-mile nature trail through the dunes. This park is one of the more remote state parks in Michigan. One must walk over a mile from the car park to reach it. This remoteness limits the number of visitors each year. In 1996, Saugatuck State Park had 71,000 visitors. The more easily accessible, neighboring Holland State Park had over 1.25 million visitors.

C. **P.J. Hoffmaster State Park** has over two and a half miles of fine, sandy beach along Lake Michigan. It also has towering sand dunes and stairs leading to the top of a high dune overlook. The Gillette Sand Dune Visitor Center is located here. It has hands-on exhibits and is a great place to learn about Michigan dunes.

D. **Silverlake State Park** is on Lake Michigan and has over 1,500 acres of "Sahara Desert-like dunes" that can be explored by foot or by vehicle. This is one of the few dune areas that allow off-road vehicles.

E. **Leelanau State Park** has over 1300 acres located at the "Tip of the Little Finger" as the Leelanau Peninsula is sometimes called. The word Leelanau is the Native American word for "A Land of Delight" which is a phrase that certainly suits this park. It features the Grand Traverse Lighthouse and Museum, eight and one half miles of trails, and sandy beaches.

F. **Brimley State Park** is a 151-acre park located on Lake Superior's Whitefish Bay. It is one of the Upper Peninsula's oldest state parks with the initial 38 acres established in 1923, donated by the Village of Brimley. This park is an excellent example of Lake Superior dunes.

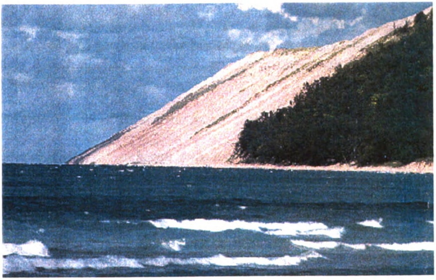
G. **P.H. Hoeft State Park** is a 301-acre park on the Shores of Lake Huron. It is a heavily wooded park with over one mile of sandy shoreline. This was one of the first 14 Michigan State Parks. The original property was donated by lumber baron Paul H. Hoeft in 1922.

H. **Alber E. Sleeper State Park** features a half-mile beach of fine sand along Lake Huron. It also has a four-mile nature trail that runs through old dune ridges where vegetation changes from wetland to forest.

I. **Sterling State Park** is Michigan's only state park on Lake Erie. Here the dunes are small and most of the shoreline is wooded. Many naturalists enjoy this park because of the abundant birds and wildlife that live amongst the bogs and marshes.

There are two National Lakeshores in Michigan where you can also enjoy and study dunes.

1. **Sleeping Bear Dunes National Lakeshore** is most famous for its massive coastal sand dunes, with bluffs towering 460 feet above Lake Michigan. The park also has a diverse landscape of smaller inland lakes, streams, and forests, and it is home to numerous plant and animal species. The entire park stretches for 35 miles along Lake Michigan.



A Chippewa Indian legend relays the history of the dunes in a story about a mother bear and her two cubs who tried to swim across Lake Michigan. The mother bear finally reached the shore and climbed to the top of a bluff to wait for her cubs who had unfortunately drowned on the way. The dune is the sleeping mother bear and the Manitou Islands represent the cubs.

Sleeping Bear Dunes National Lakeshore has received outstanding recognition in the last several years. Consumer Reports ranked the park second among the best lakeshore and seashore parks in the country (Point Reyes National Seashore in California was ranked first). In addition National Geographic Traveler called M-22, the road that winds through Sleeping Bear, one of the best scenic drives in the nation.

2. **Pictured Rocks National Lakeshore** is a 73,000-acre park that stretches along 42 miles of the Lake Superior shoreline. This was the country's first National Lakeshore, authorized in 1966. It is open year round. In 1996 over half a million people visited the park.

Pictured Rocks National Lakeshore features multicolored sandstone cliffs, beaches, sand dunes, waterfalls, inland lakes, wildlife and hardwood forests. The rocks for which the park is named rise 50 to 200 feet above Lake Superior and many have been eroded into caves and arches and other shapes that resemble castles and fortresses. Most of the shoreline is characterized by these cliffs; however there are also 12 miles of sandy beach known as the Grand Sable Dunes.

Credits:

Data was collected by site visits to the Michigan dunes in 1997-1998; fieldwork was conducted by Alison E. Philpotts. Additional information was gathered from the following sources.

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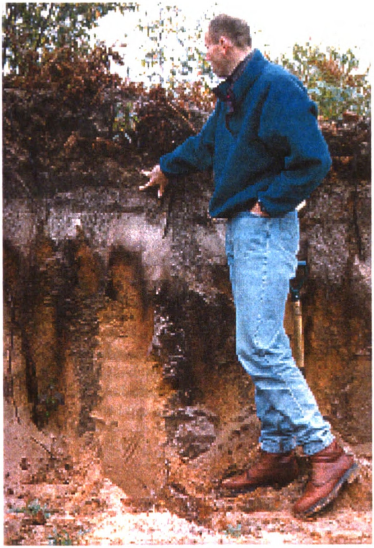
Section 2: Geology and Geomorphology of Coastal Dunes



Section 2: Geology and Geomorphology of Coastal Dunes

1. Origin of the sand
2. How dunes form
3. The anatomy of a coastal dune environment
4. Types of dunes in Michigan
5. Dunes over time

Origins of the Sand

In the history of the earth, there have been periods known as "ice ages" that have had extremely cold temperatures. When the temperatures remain colder than normal, ice and snow build up in the polar regions and form glaciers. The glaciers eventually spread southward over Canada.

Michigan was directly in the path of these glaciers during the last ice age and was repeatedly buried under sheets of ice. The Pleistocene epoch is the term for this last ice age period and it occurred from 2 million to 10,000 years ago. Scientists use carbon and oxygen dating techniques to determine when the ice advanced. They have recorded 11 separate ice advances. The last glacial period, dating to 21,000 years ago, extended as far south as southern Ohio. By 15,500 years ago the ice extended only as far south as northern Ohio and by 13,000 the glacier extended only to the northern potion of Michigan's Lower Peninsula. By 11,000 years ago temperatures continued to warm and the glacier reached only to the tip of the Michigan's Lower Peninsula and continued to recede north in the following years.

As glaciers spread south, they moved with a very slow grinding motion similar to that of a huge bulldozer. They enlarged the paths they followed and carved out wide deep basins. When the glaciers receded, water filled these basins and formed the Great Lakes. Looking at the shape of the Great Lakes you can almost imagine them as remnants of huge lobes of glacial ice over the area.

The sediment that the glaciers bulldozed was deposited as large piles of sand and rock debris. Much of this debris is still visible, for it forms the hills in the northern portion of the Lower Peninsula and the Upper Peninsula of Michigan. The remaining sediment was left in the basin to be further ground up by wind and wave action in the Great Lakes. This debris created the sand for Michigan's dunes.

How Dunes Form

The coastal sand dunes of Michigan are formed by the prevailing westerly winds that blow across the Great Lakes. The water and waves in the Lakes erode and carry new sediment. Once this sediment is on land, the wind moves the sand particles and forms dunes.

The way in which sand is moved by the wind depends on the size of the sand particles and the wind velocity.

1. The smallest particles are usually transported in **suspension**. These particles are so small and light that the wind can carry them along and they do not touch the ground surface until they have been carried a fairly long distance.

2. The medium size sand particles travel by **saltation**. This is an asymmetrical, or uneven, path. First, the particle is lifted off the ground in a steep upward direction.

Then, gravity pulls the particle down, decreasing its velocity and the sand grains fall in a less-steep arc toward the ground. On impact of landing, the moving sand particles transfer momentum and energy to dislodge other stationary sand particles and the movement is continued in the direction of the wind.

3. The largest sand particles are transported by **creep**. This occurs with sand grains that are too heavy to be lifted from the surface. Instead, the sand particles may be pushed along by the wind.

In any case, the wind moves the particles until there is no longer enough energy to overcome gravity. The sand is then deposited. This usually occurs in areas where the wind is blocked, such as behind a tree or log, in a grassy area, or over the crest of a hill. It is in these areas that deposits of sand grow into dunes. Once a dune begins to form it provides its own barrier to the wind. The downwind side of the dune is protected from the wind. Sand particles on the upwind side are transported by the wind and deposited. As long as the wind is carrying sand, the dune continues to move.

The Anatomy of a Coastal Dune Environment

Coastal sand dunes are created when sand particles are eroded and deposited by water and carried by wind. They are closely associated with the shoreline of a body of water. It is important to know the different parts of a coastal environment to understand the dune's physical relationship to the water.

The coastal environment is divided into three main parts: the offshore, foreshore, and backshore. The **offshore** is the part located beneath the water. In this part of the coastal environment, only water is carrying and depositing the sand particles.

The **foreshore** is the area that ranges between the minimum and maximum water level. The sand particles in this area are carried and deposited by both wind and water. The "berm" is the farthest point inland that waves reach during high tide and is relatively steep. Usually the berm appears as a linear ridge running parallel to the shoreline. It is formed by the waves and is not a dune. Some sand from the foreshore, however, will be dry enough to be blown inland and provide new sediment for dune formation.

The area inland from the berm is called the **backshore.** Here, wind is the only dynamic agent carrying and depositing sand particles. It is in the backshore that dunes are formed.

All dunes are shaped with a less-steep slope in the windward direction (the direction the wind is coming from) and a steeper slope in the leeward direction (the opposite direction). The gentle windward slope is usually less than 10 degrees and is continually being reshaped with sand grains moving up the slope. The leeward side of the dune is steeper because once the sand grains reach the top, or crest, of the dune, the wind cannot carry them and they drop. The leeward side usually has an angle between 30 and 40 degrees.

Types of Dunes

Dunes are classified into types depending on their overall shape or pattern. Dunes can form many different shapes based on environmental conditions. Some of the conditions include the amount of available sand, wind direction, wind velocity, and the distribution of vegetation and past climate environments. In Michigan you will find three types.

1. **Beach Ridges** are found perpendicular to the shoreline and are directly related to the offshore, foreshore, and backshore parts of the coastal environment. Some beach ridges are found very high above the water and they may be a long way from today's coastline. This distance occurs because water level has changed over the years. In the past, water level was higher; today's coastline would have been under water in the past. What we see today is a series of giant steps, like a staircase, moving down from the higher backshore to the lower water level. Each step represents a distinct time period.

2. **Parabolic Dunes** develop from constant wind erosion. Parabolic dunes are found along Michigan's western coastline. The environmental conditions of wind coming from the direction of Lake Michigan combined with abundant vegetation to trap sand results in the formation of large dunes. Many of these dunes reach a height of 50 feet or more. The abundant sand and vegetation help form these dunes into a distinct shape. The shape is that of a crescent, or a parabola, hence the name "parabolic

dune." The tips or horns of the dunes are located upwind and the main body of the dune is located downwind. The vegetation helps to stabilize the dune and hold the tips upwind.

3. **Perched Dunes** are the extremely high, impressive dunes found at places like Sleeping Bear National Lakeshore and at Pictured Rocks National Lakeshore's Grand Sable dunes. Perched dunes form in two steps. First the water level lowers and the waves from the Great Lakes erode the freshly exposed shoreline, making a steep bank and producing abundant sand. This sand is then moved by the strong winds that blow across the Lakes. The wind moves the sand particles high up the steep bank face and deposits it on a high bluff.

Dunes Change Over Time

Geological changes often occur slowly over millions of years, but many sand dunes change quickly. In fact, dunes are constantly changing. By studying both younger active dunes and older, stable dunes, scientists can learn about past environments.

Changes in water level results in changes in the position of the offshore, foreshore, and backshore. Remember that waves in the lake carry sand to the shoreline and that wind moves the particles to form dunes in the backshore. In times of high water levels, new backshores are created. Today, water level is lower than in the past and the old backshores are now higher than the newer, younger dunes that are forming along the coastline.

Glaciation has changed water levels. The enormous weight of the ice in a glacier presses the land down and submerges it below the water. When the glaciers melt, the weight is lifted and the land re-emerges from the water.

In other words, water level rises during glaciation and lowers when the glaciers recede. This changes the location of dunes on the land and is the reason that Michigan has a series of beach ridges along many of its coasts.

Vegetation is important for studying the development and change in dunes and for estimating the ages of the different water levels. As dunes are pushed by the wind they migrate and often bury objects in their path. Trees are often covered and killed by shifting sands. Many years later, as the dunes continue to migrate, dead trees are exposed leaving behind ghost forests as stark reminders of the past presence of dunes. Radiocarbon dating can be used on the dead trees to determine when the dune migrated over the trees. Scientists can use radiocarbon dates to estimate the chronological history of the dunes and can infer about past environments.

Credits:

Data was collected by site visits to the Michigan dunes in 1997-1998; fieldwork by Alison E. Philpotts. Additional information was gathered from the following sources.

Anderton, J. B., and Loope, W. L., 1995. "Buried soils in a perched dune fields as indicators of Late Holocene lake-level change in the Lake Superior basin." *Quaternary Research,* vol. 44, p. 190-199.

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Section 3: Plant and Animal Life on the Dunes

Dune Ecosystems

The coastal dunes in Michigan are part of the Great Lakes Ecosystem. An ecosystem consists of the plant and animal life living in a stable community that interacts with the air, land, and water. It also includes the people who live there. It is essential to understand the interrelationships between these components to ensure a high quality of life, a healthy environment and a productive, sustainable economy.

The Great Lakes ecosystem extends outside of Michigan's borders to include eight U.S. states and two Canadian provinces. Although the international border separates distinct political boundaries, a rich, integrated resource base and manufacturing region has developed. The Great Lakes contain one-fifth of all the fresh water in the world with hundreds of tributaries and thousands of smaller lakes surrounding them. The ecosystem contains rich forests and wilderness areas that are home to an abundant and diverse wildlife. It is a region of productive agricultural land and mineral deposits, and it is North America's industrial heartland. Over 32.4 million people live in the area, and the region supports a multi-billion dollar recreation and tourism industry.

The Great Lakes and its encompassing ecosystem are so large that it is even visible to the naked eye from the moon. It greatly affects our way of life, as well as all aspects of the natural environment, from weather and climate to wildlife and habitat. Despite their size and power, the lakes are fragile. Industrial practices, resource extraction, urbanization, de-forestation, introductions of exotic species, destruction of natural areas, and the contamination of the air, water and soil all affect and stress the ecosystem.

The coastal dunes are vital parts of that interdependent ecosystem. The plants and animals that live in and around the dunes are all intertwined within the larger system. You will learn about human involvement in the ecosystem in Section 4: Dune protection and sustainable maintenance. In this section we will look at the plants and animals.

Native Plants

Plant life changes and becomes more abundant on the dunes as you go inland.

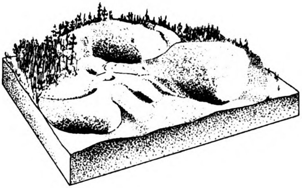
Only the most hardy plants reside in the foreshore area. Despite the occasional wave, this mid-beach section has a hot, dry, windy surface. The plants that live here have small nondescript flowers and small seeds.

Permanent plant life is found inland from the backshore. Beach grass is one of the more common plants found along Michigan's dunes and it plays an important role in young, active dune development. The grass builds dunes by acting as obstacles and creating protective areas downwind where sand particles can no longer be carried. The roots also hold sand in place, stabilizing the dunes. The underground roots of beach grass sprout offshoots that grow off in all directions and form new grass. One plant may eventually spread over twenty feet.

Once the beach grass has stabilized the dune, cherry bushes, junipers, prickly pear cacti, evening primroses, and thistles inhabit the area. Each plant community in turn creates a new environment that is conducive to the succession of new plants. Cottonwood trees are usually the first trees to survive moving sands and dune building. It is a highly adaptable tree, relatively drought resistant and tolerant to dry sands, yet it can endure moist soils. Jack pine, followed by red pine and aspen trees are the next to colonize. Farthest inland is a mix of hardwood trees including oak, maple, and beech trees. The Paw Paw tree is a unique native tree in North America. It grows only in the southern third of Michigan's Lower Peninsula and is the only member of the "tropical custard apple" family that lives outside of the tropics.

Amongst the bushes and trees of the backshore grows a variety of plant life including flowering plants, ivy, and mushrooms. Irises, orchids, and lady slippers make the dunes a rainbow of colors in the spring and summer. Berries and fruit provide food for birds, animals, and people. Poison Ivy is abundant throughout the ecosystem and should be avoided, for it often causes irritation to the human skin.

In areas where the vegetation roots have been disturbed, either by natural or human causes, the wind carries away the protective vegetation. As root disturbance continues, a large horseshoe-shaped basin develops. These rounded pits are commonly called **blowouts**. As the sands migrate, the blowout areas becomes deeper and larger. Blowouts are prominent features along the shores.



Native Birds and Animals

Michigan's coastal dunes are home to a vast number of native birds and animals. The foredune is a harsh environment for plants, and only a few animals live here. Sandpipers, plovers, and sanderlings dart back and forth between waves. Tiger beetles, burrowing spiders, and ants can also be seen just out of reach of the waves. In the fall, ladybird beetles inhabit the driftwood deposited in the sand.

In the more vegetated areas inland from the backshore one finds most of the dune's wildlife. The bushes and trees provide food, protection and nesting sites for many of the birds and animals that frequently visit the water and foredune area. Loons, deer, raccoons, black bear, gray wolves, fox, opossums, and squirrels are common residents to the forested areas.

Let's take a closer look at a few of Michigan's dune residents.

Loons can be seen in the numerous lakes, bogs, and marshes found amongst the dunes. Both the male and female adult loons have black and white bodies with a white breast, while younger birds have gray backs with a white breast. Their eyes are characteristically red. Loons are often found breeding in the coastal dune environment because of its abundant fish, undeveloped shoreline, and inland lakes. They prefer either lakes with small islands or bog mats that are inaccessible to egg-eating predators.

On average, loons weigh around nine pounds, and reach three feet in length with a five-foot wingspan. Their webbed feet are located at the back of their bodies instead of underneath which makes them extremely powerful swimmers. They are skillful at catching their diet of fish, frogs, crayfish, leeches and aquatic insects, and they are able to dive to 200 feet and stay underwater for up to five minutes. Unlike most birds, which have hollow bones, loons have solid bones, reducing their buoyancy. When they compress their feathers, and force the air from their lungs, loons are able to move through the water with only their heads showing above the surface.

Easily disturbed and stressed, adult loons may desert their nest if approached too closely by a human being or water vehicle. As settlement in Michigan has increased, the loon's breeding range has decreased. The loon was added to Michigan's threatened species list in 1987. A loon recovery plan was created that includes measures such as protection of current and potential breeding lakes, reduction of causes of mortality, and public educational programs. Everyone can help to protect the loon by giving them the seclusion they need, and letting others know if there is a nest nearby so it can be avoided.

Raccoons are the most common four legged creatures in the coastal dune forest. Raccoons have distinct markings, including a ringed tail and black spots over the eyes that look like a mask. Mostly active at night, raccoons are usually seen close to water. The fingers on the front paws are highly sensitive and raccoons use them underwater to search and catch food. A typical raccoon diet includes wild berries, eggs, crayfish, and frogs; and, they are notorious for raiding campsites and taking human food.

Another dune resident is the black bear. An estimated 12,000 black bears, including cubs live in Michigan. Most are found in the Upper Peninsula, but 15 percent of the population is in the northern Lower Peninsula. Many of these bears make their homes in the thicker forests of the coastal dunes. Generally, black bears are not dangerous, but they can be aggressive in their search for food during years when supplies are scarce. In the state parks campgrounds they can sometimes cause disturbances because they are attracted to garbage cans, food stored in outbuildings or tents, pet food, and backpacks containing food. They often leave the area once the food that has attracted them is removed. There are few records of bears injuring or killing people in Michigan.

A returned species to the dune ecosystem is the gray wolf (Canis lupus). Gray wolves are the largest member of the canid family (wild dogs), which also includes coyotes, and red and gray foxes. Adult gray wolves average 30 inches in height at the shoulder and weigh 65 pounds. Their feet are generally 3 1/2 inches wide and 4 1/2 inches long, which provides an easy way of differentiating them from coyotes, whose feet are only 1 1/2 inches wide and 2 1/2 inches long.

Michigan wolves generally eat deer, beaver, hare, and rodents and other small mammals, but may also eat woodchuck, muskrat, coyote, raccoon, insects, nuts, berries and grasses. This diet is plentiful in the dune ecosystem. While wolves can go for a week without eating, when they do eat a meal, it can contain up to 20 pounds of meat.

Wolves once resided in all 83 Michigan counties, but the loss of habitat and the direct extermination through hunting caused the gray wolf to be virtually eliminated from the state. By 1840 they could no longer be found in the southern portion of the Lower Peninsula. By 1910 they had completely disappeared from the Lower Peninsula, and by 1960 they had nearly vanished from the Upper Peninsula. The last known new pups before the 1990s reintroduction of wolves in the state, were born in the Pictured Rocks National Lakeshore in the mid-1950s.

Gray wolves have been protected in Michigan since 1965 and have been listed on the Federal endangered species list since 1974. Several attempts were made to reintroduce gray wolves into Michigan. One attempt in 1974 relocated four wolves from Minnesota to northern Marquette county, Michigan but it failed.

In the 1980s more wolves were relocated, but they did not form packs or birth pups. The only verified sightings of wolves, other than on Isle Royale, were of individual animals, but in 1989, the tracks of two wolves traveling together were seen. In the spring of 1991, this pair produced pups, the first to be documented on the mainland of Michigan in 35 years. In 1997, a winter survey reported 112 wolves.

Introduced Species

Introducing non-native plant and animal species into a stable ecosystem can be potentially dangerous and disruptive. Sometimes species are introduced intentionally to help cure a problem. Although an introduction may have good intentions, the result may be negative. For example, black pines are not native to the dunes but were introduced to help stabilize them. Dunes are suppose to move around and plants should adapt to the shifting sands, so stabilizing the dunes was not a good idea in the first place. Today the pines are taking over and spreading quickly.

Another example of a disruptive non-native species is the garlic mustard plant. Garlic mustard is a European species that invades shady areas. The plant produces white flowers that can yield between 300 to 1,000 seeds per plant. The flowers are self-pollinating allowing the population to boom. If it is not eradicated, garlic mustard threatens to destroy this fragile ecosystem.

New species can also enter a stable ecosystem by unintentional transportation. With all the industrial trading and transporting that occurs in the Great Lakes, it is not surprising that some boats might also be carrying new animal species, insects, or plant seeds. These new species may destroy the delicate ecosystem.

Studying the Dune Ecosystem

The dune ecosystem is an exciting and changing environment. Lets look at what you might see if you visited the dunes throughout the year.

In January and February, only a few animals wander far from their nests, trees, holes, or dens. Raccoons, skunks, and mice are the most commonly seen. Young owls and bear cubs are born, but they do not venture out into the cold.

In March and April migrating birds, such as seagulls return to the dunes, and sap can be collected from maple trees. Migrating fish, including smelt, trout, and salmon, provide interesting viewing and fishing.

By May and June wild flowers and trees have bloomed. Aspen trees are the first to turn bright green, and migratory birds return from winter stays in warmer climates. Deer fawns are born in early May and black flies hatch by mid-May.

In July and August blueberries and huckleberries ripen in pine forests along the lakeshore, and thimbleberries and raspberries ripen along roadsides and forest clearings.

By September and October, many birds begin to migrate south. Black flies are gone and mosquitoes are fewer, but horse, deer, and stable flies are numerous. The leaves change colors, and beechnuts ripen. Black bears climb trees to feed on these nuts, and often you can see their claw marks on the smooth beech bark.

In November and December, snow usually covers the ground. Loons congregate on bays in large groups as they migrate south. The snowshoe hare changes its fur color from gray to white, and bears begin to hibernate.

Michigan dunes are a fun place to study plant and animal life throughout the year. In the spring and summer, the flowering plants are at their peak. The fall is an ideal time to go leaf collecting, and in the winter, fresh snowfalls provide an ideal way to study animal tracks. Most of the State Parks have posters or bulletin boards to help visitors identify the plants and animals throughout the year.

Credits:

Data was collected by site visits to the Michigan dunes in 1997-1998; fieldwork conducted by Alison E. Philpotts. Additional information was gathered from the following sources.

Bloom, Arthur L. 1991. *Geomorphology. A systematic Analysis of Late Cenozoic Landforms.* (2nd ed). Prentice Hall: New Jersey.

The Detroit News. 1997. "Nature lovers delight in dunes," Wednesday October 29, p. 6C.

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Section 4: Dune Protection and Sustainable Maintenance

Section 4: Dune protection and sustainable maintenance

1. Land use activities
2. Protection measures

Land Use Activities

The coastal dunes of Michigan are a vital component to the health of the Great Lakes. The richness of the Great Lakes and the land around them has attracted people to this area since the glaciers retreated northward. Numerous Native American tribes relied on the resources in the region to survive. During white settlement, the land was used heavily for logging, fishing, fur trapping, and mining. Today the region is North America's industrial hub and remains a center for tourism and recreation. Human land use is directly connected to the Great Lakes ecosystem. This is a fragile system and protective measures are necessary to ensure the current and future health of the region.

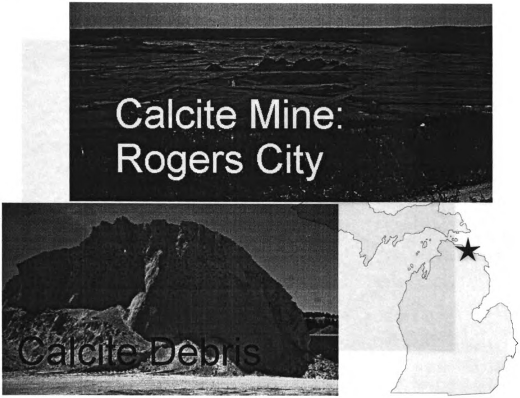
The Great Lakes region was inhabited by Native Americans as early as 11,000 BC. Dietary subsistence depended upon hunting, fishing, trapping, gathering seeds, nuts, berries, and roots, and eventually included some agriculture. Archeological remains indicate that stone, wood, and copper was used to create tools, weapons, and boats. Periods of distinct cultures and tribes have been studied and recorded. Today, there are several Native American reservations located in Michigan, and numerous museums and cultural events give insights into how early inhabitants utilized the Great Lakes and the coastal dune system.

In the 1600s and 1700s French and English explorers came searching for furs and minerals. In the 1800s, the demand for timber attracted lumber barons who bought vast forests of white pine, beech, and maple. By the 1890s, boomtowns located along the shoreline supported sawmills that produced millions of board feet of lumber yearly. Other businesses and industries began to flourish in the region as well. Wooden-hulled freighters and side-wheelers transported lumber and iron to distant markets. To help ships navigate, the U.S. Life Saving Service (later to become the U.S. Coast Guard) built lighthouses along the lakeshore. By the early 1900s deforestation was a problem and many forest barons moved elsewhere.

Although forests were in decline, Michigan remained rich in other resources. Sand and gravel are found throughout the state, and limestone is common in the Upper Peninsula and the northern portion of the Lower Peninsula. Other resources found in the Upper Peninsula include iron ore and marble.

Petroleum and natural gas are important minerals found in the Lower Peninsula. The state's numerous bogs contain abundant resources of peat. In addition, other mineral deposits include copper, clay, coal, gypsum, magnesium, shale, and silver. Most of these products are transported in the Great Lakes.

One example of the importance of mining today can be seen in the production of limestone, where Michigan ranks fourth in the nation. In fact, the Calcite Quarry at Rogers City, which produces limestone and dolomite, is the largest stone quarry in the world. Limestone and dolomite are used in steel, sewage treatment plants, and in everyday products such as paper, glass, paint, varnish, soap, detergents, baking powder, and beet sugar. The proximity to the Great Lakes makes it easy to transport the finished product to distant markets. Many quarries such as the one in Rogers City are shipping between 1/2 to 1 billion tons of material a year.



The Great Lakes are vital to Michigan's economy. Michigan's ports are actively shipping raw materials, such as iron ore and limestone, and receive products such as coal. Michigan is one of the leading states in manufacturing, which accounts for about 27 percent of the state's gross annual production and it provides over 968,000 jobs to state residents. Manufactured goods must be transported, usually on the Great Lakes, to national and international markets. The extraction, production and transportation of minerals and the manufacturing of goods produces garbage, pollution, acid rain, and oil slicks that have harmful impacts on the dune ecosystem. The impacts are most noticeable when schools of fish digest pollutants, become ill, and are washed upon the shore. The health of the Great Lakes is important to the plant and animal life that reside in the dune ecosystem.

Another major land use activity in the dune area is recreation. The State Parks offer a variety of day and night activities. In the summer, picnicking, swimming, hiking, canoeing, boating, hang gliding, and camping are just a few of the activities offered at most of the State Parks. Many of these parks have concession stands, cabins, and toilet facilities. In the winter months, dune activities include snow shoeing, cross-country skiing, and ice fishing. Millions of visitors utilize the parks throughout the year, which in turn brings pollution and vegetation disruption to the dunes. Remember that vegetation helps stabilize the dune, so if it is destroyed the dunes will migrate at a faster than normal rate. Most State Parks have erosion control areas or fences to protect the vegetation. Not everyone, however, obeys the signs.

One activity that is extremely harmful to the dune environment is the use of off-road vehicles. In a few areas around the state, off-road vehicles, such as dune buggies and jeeps, are allowed on the dunes. Tire tracks destroy dune vegetation and can leave scars that last many years. The state does have an additional tax placed on off-road vehicle licenses. This tax is used to help re-vegetate areas, but a little damage can ruin years of dune building.

New housing development is another land use activity that is currently affecting the coastal dune ecosystem. Expensive housing units are being constructed along all four coasts of the Great Lakes. These properties are being used for both year-round residency and for vacation homes. Talks are currently underway to exchange 204 acres of Sleeping Bear National Lakeshore with 160 acres of wetlands along the Crystal River. The National Lakeshore property is estimated to be worth over $4 million and the land is adequate for residential building structures. The wetlands area, however, is estimated to be worth only $500,000 and it can not support any development. It must remain as a

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Despite the increasing number of coastal homeowners, it is important to recognize the power of a dynamic system, such as coastal dunes. Similar to the difficulties in protecting people and property in flood zones or near active volcanoes, there are difficulties protecting people and property in coastal dunes areas. Lake level changes are a great concern to property owners. If the lake level rises, waves can erode away properties and even destroy entire houses. Even in times of constant lake levels, properties are still at risk because coastal dunes are active and always migrating. Structurally sound buildings can not always escape the influences of windblown sand. The U.S. Coast Guard building is now located in Glen Haven after it was moved from Sleeping Bear Point in 1931 because migrating dunes threatened to cover it.

Protection measures

The industrial growth in Michigan and the rest of the United States and the increase in tourism have had negative impacts on the environment. Again, the ecosystem of the Great Lakes is fragile and human disruption to the air, water, land, plant, and wildlife by the 1960s was noticeable. Environmental laws were needed. The United States Clean Water Act of 1970 was seen as an initial starting point for environmental improvements. The goal of the Act is to make the nation's lakes, rivers, and streams safe for fish, shellfish, wildlife, and people.

In Michigan, several steps were initiated to protect the coastal dune environment. The Land Resource Program and the Coastal Zone Management Program were established. The goal is to protect sensitive coastal resources such as wetlands and sand dunes and regulate development in erosion-hazard areas. It also aims to help improve public access to the dunes, enhance waterfront revitalization and increase public awareness of coastal resources and issues. The United States Coast Guard also patrols and monitors the Great Lakes environment.

In 1976, Michigan passed the "Sand Dune Protection and Management Act" to provide for the study, protection, management, regulation, and reclamation of sand dunes. In addition, the act provides permits for local zoning and mining. In this Act dunes are recognized as a unique, irreplaceable, and fragile resource that provides significant recreational, economic, scientific, geological, scenic, botanical, educational, agricultural, and ecological benefits. These benefits are to be shared by Michigan residents, visitors and future generations.

Another protective measure is to increase the number and the size of State Parks in Michigan. The mission of the State Parks is to acquire, protect and preserve the natural, historic, and cultural features of Michigan's unique resources and provide public recreation and educational opportunities. Michigan has many State Parks and two National Lakeshores dedicated to protecting the coastal dunes.

Not all protective measures have to be large projects or government acts. Everyone can help make a difference by studying the environment, learning about the coastal dune ecosystem, and respecting nature when we visit the dunes. Remember to look and observe the native plants and animals without destroying their habitat. Remember to walk only in designated areas to avoid destablizing the vegetation. And please remember to always pick up any garbage you may have created or that others have left behind.

Credits:

Data was collected by site visits to the Michigan dunes in 1997-1998; fieldwork was conducted by Alison E. Philpotts. Additional information was gathered from the following sources.

Arbogast, A. F. 1996. Lectures given in Regional Geomorphology course, Michigan State University.

Eblen, Ruth and William Eblen. 1994. "Clean water act" in Ruth Eblen and William Eblen (eds) *Encyclopedia of the environment,* Houghton Mifflin Company: Boston, Massachusetts.

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Winckler, Suzanne.1989. *The Smithsonian Guide to Historic America: The Great Lakes States,* Stewart, Tabori, and Chang: New York.

APPENDIX B

Test Questions:

Group 1 Pretest Questions given to half of the dyslexic students and half the non-dyslexic students.

1. Michigan has about how many miles of coastline?
   a. 1,000
   b. 2,300
   c. 3,200
   d. 5,000
2. The only State Parks listed here that allows off-road vehicles is:
   a. Ludington State Park
   b. Silverlake State Park
   c. Harrisville State Park
   d. Port Crescent State Park
3. The Capitol of Michigan is
   a. Lansing
   b. Detroit
   c. Ann Arbor
   d. Grand Rapids
4. If you were a contractor in Michigan looking for bogs and peat you would first look along the coast of Lake
   a. Huron
   b. Superior
   c. Michigan
   d. Erie
5. If you were going to make a State Park in Michigan dedicated to rock climbing you would look for land along Lake
   a. Huron
   b. Superior
   c. Michigan
   d. Erie
6. The glacial ice of the last Ice Age retreated north from Michigan's Lower Peninsula as late as
   a. 5,000 years ago
   b. 11,000 years ago
   c. 21,000 years ago
   d. 600,000 years ago
7. Between 15,00 and 11,00 years ago the glaciers moved
   a. north
   b. south
   c. east
   d. west

8. When a dune is at a lake's edge, the portion of the coastal environment where sand movement is occurring by the force of water only is called the
   a. offshore
   b. foreshore
   c. backshore
   d. middleshore
9. If there was a high wind velocity you would expect a small sand particle to get transported by
   a. suspension
   b. saltation
   c. creep
   d. pull
10. At what degree Fahrenheit does water freeze?
    a. 40
    b. 32
    c. 23
    d. 0
11. More permanent vegetation is found in the
    a. offshore
    b. foreshore
    c. backshore
    d. middleshore
12. The Paw Paw tree is native to
    a. All of Michigan
    b. Michigan's Lower Peninsula
    c. Michigan's Upper Peninsula
    d. All of North America
13. Michigan is in which direction from Ohio
    a. north
    b. south
    c. east
    d. west
14. The introduced black pine species has negative effects on Michigan's dunes because
    a. the dunes tend to migrate faster
    b. the dunes should migrate but instead remain stationary
    c. the black pines yield too many seeds and over-populate the rest of the dunes
    d. the black pines provide too much shade
15. In November and December snowshoe hares change fur color from
    a. gray to white
    b. white to gray
    c. black to white
    d. gray to black

16. People have lived in the Great Lakes region for the last
    a. 250,000 years
    b. 25,000 years
    c. 11,000 years
    d. 2,300 years
17. The foreign country bordering Michigan is
    a. England
    b. Mexico
    c. Cuba
    d. Canada
18. In Michigan, manufacturing accounts for what percent of the state's gross annual production?
    a. 10
    b. 27
    c. 54
    d. 72
19. In 1976 Michigan passed what act to provide for the study, protection, and management of the sand dunes
    a. Clean Water Act
    b. Coastal Zone Study Act
    c. Sand Dune Protection and Management Act
    d. Research and Endeavors Act
20. Talks are underway about exchanging land in the Sleeping Bear Dunes National Lakeshore because the land is
    a. not worth much
    b. all wetlands
    c. too big
    d. a place to build expensive houses

Group 1 Posttest Questions given to half of the dyslexics and half of the non-dyslexic subjects, given after all sections and section tests.

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    c. Harrisville State Park
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    c. too big
    d. a place to build expensive houses

Group 2 Pretest Questions given to half of the dyslexic students and half the non-dyslexic students.

1. The park that receives less visitors because it is remote and hard to get to is
    a. Warren Dunes State Park
    b. Saugatuck State Park
    c. Brimley State Park
    d. Sterling State Park
2. Leelanau is a Native American word for
    a. Grand dune
    b. Large water
    c. Little finger
    d. Land of delight

3. The Grand Sable dunes are locate in what direction from Sleeping Bear Dunes National Lakeshore
   a. north
   b. south
   c. east
   d. west
4. If prevailing winds came from the east rather than the west you might expect to find the most dunes in Michigan along Lake
   a. Huron
   b. Superior
   c. Michigan
   d. Erie
5. The Capitol of Michigan is
   a. Lansing
   b. Detroit
   c. Ann Arbor
   d. Grand Rapids
6. If water level did not change over time we would not see this type of dune in Michigan
   a. beach ridges
   b. parabolic dunes
   c. perched dunes
   d. stable dunes

7. The motion that carries sand particles along in the wind in an arc shaped motion is called
   a. suspension
   b. saltation
   c. creep
   d. pull
8. The windward slope of a dune is often at an angle of about
   a. 0
   b. 10
   c. 30
   d. 60
9. The impressive dunes found at Sleeping Bear Dunes National Lakeshore are
   a. beach ridges
   b. parabolic dunes
   c. perched dunes
   d. stable dunes
10. What degree Fahrenheit does water freeze
    a. 40
    b. 32
    c. 23
    d. 0

11. One of the first plants to inhabit the backshore is
    a. cottonwood trees
    b. jack pine
    c. junipers
    d. beach grass
12. Rounded pits where vegetation has been disturbed and removed are called
    a. Horseshoes
    b. Sand basins
    c. Blowouts
    d. Bowls
13. Until the recent effort to return gray wolves back to Michigan, the last known wolves were born in
    a. Traverse City
    b. The thumb
    c. Sleeping Bear National Lakeshore
    d. Pictured Rocks National Lakeshore
14. Michigan is what direction from of Ohio
    e. north
    f. south
    g. east
    h. west
15. Normally, migratory birds return to the dunes around these months
    a. March and April
    b. May and June
    c. July and August
    d. September and October
16. In the 1600s and 1700s people exploited ______ from the region
    a. Lumber and steel
    b. Furs and Minerals
    c. Archeological remains
    d. Sand
17. The foreign country bordering Michigan is
    a. England
    b. Mexico
    c. Cuba
    d. Canada
18. At Rogers City, Michigan, one finds the world's largest
    a. Calcite mine
    b. sand dune
    c. petroleum reserve
    d. gypsum mine
19. Housing for both vacation and year-round residency is being built along
    a. Lake Michigan
    b. Lake Huron
    c. Lake Superior
    d. All four Great Lakes

20. One of the most harmful recreation activities to the dunes is
    a. bathing
    b. camping
    c. hang gliding
    d. dune bugging

Group 2 Posttest Questions given to half of the dyslexic students and half the non-dyslexic students, given after all four sections and section tests.

1. Leelanau is a Native American word for
    a. Grand dune
    b. Large water
    c. Little finger
    d. Land of delight
2. If water level did not change over time we would not see this type of dune in Michigan
    a. beach ridges
    b. parabolic dunes
    c. perched dunes
    d. stable dunes
3. At Rogers City, Michigan, one finds the world's largest
    a. calcite mine
    b. sand dune
    c. petroleum reserve
    d. gypsum mine
4. If prevailing winds came from the east rather than the west you might expect to find the most dunes in Michigan along Lake
    a. Michigan
    b. Superior
    c. Huron
    d. Erie
5. The park that receives less visitors because it is remote and hard to get to is
    a. Warren Dunes State Park
    b. Saugatuck State Park
    c. Brimley State Park
    d. Sterling State Park
6. The impressive dunes found at Sleeping Bear Dunes National Lakeshore are
    a. beach ridges
    b. parabolic dunes
    c. perched dunes
    d. stable dunes
7. The motion that carries sand particles along in the wind in an arc shaped motion is called
    a. suspension
    b. saltation
    c. creep
    d. pull

8. The windward slope of a dune is often at an angle of about
   a. 0
   b. 10
   c. 30
   d. 60
9. Rounded pits where vegetation has been disturbed and removed are called
   a. Horseshoes
   b. Sand basins
   c. Blowouts
   d. Bowls
10. The Grand Sable dunes are located in what direction from Sleeping Bear Dunes National Lakeshore
    a. north
    b. south
    c. east
    d. west
11. One of the first plants to inhabit the backshore is
    a. cottonwood trees
    b. jack pine
    c. junipers
    d. beach grass
12. Until the recent effort to return gray wolves back to Michigan, the last known wolves were born in
    a. Traverse City
    b. The thumb
    c. Sleeping Bear National Lakeshore
    d. Pictured Rocks National Lakeshore
13. One of the most harmful recreation activities to the dunes is
    a. bathing
    b. camping
    c. hang gliding
    d. dune bugging
14. Normally, migratory birds return to the dunes around these months
    a. March and April
    b. May and June
    c. July and August
    d. September and October
15. In the 1600s and 1700s people exploited ______ from the region
    a. Lumber and steel
    b. Furs and Minerals
    c. Archeological remains
    d. Sand

16. Housing for both vacation and year-round residency is being built along
    a. Lake Michigan
    b. Lake Huron
    c. Lake Superior
    d. All four Great Lakes

Section 1 given to all test subjects

1. Michigan has about how many miles of coastline?
    a. 1,000
    b. 2,300
    c. 3,200
    d. 5,000
2. The park that receives the less visitors because it is remote and hard to get to is
    a. Warren Dunes State Park
    b. Saugatuck State Park
    c. Brimley State Park
    d. Sterling State Park
3. The only State Park listed here that allows off-road vehicles is:
    a. Ludington State Park
    b. Silverlake State Park
    c. Harrisville State Park
    d. Port Crescent State Park
4. Leelanau is a Native American word for
    a. Grand dune
    b. Large water
    c. Little finger
    d. Land of delight
5. If prevailing winds came from the east rather than the west you might expect to find the most dunes in Michigan along Lake
    a. Michigan
    b. Superior
    c. Huron
    d. Erie
6. If you were a contractor in Michigan looking for bogs and peat you would first look along the coast of Lake
    a. Huron
    b. Superior
    c. Michigan
    d. Erie
7. If you were going to make a State Park in Michigan dedicated to rock climbing you would look for land along Lake
    a. Huron
    b. Superior
    c. Michigan
    d. Erie

8. The Grand Sable dunes are located in what direction from Sleeping Bear Dunes National Lakeshore
   a. north
   b. south
   c. east
   d. west

Section 2 given to all test subjects

1. The glacial ice of the last Ice Age retreated north from Michigan's Lower Peninsula as late as
   a. 5,000 years ago
   b. 11,000 years ago
   c. 21,000 years ago
   d. 600,000 years ago
2. If water level did not change over time we would not see this type of dune in Michigan
   a. beach ridges
   b. parabolic dunes
   c. perched dunes
   d. stable dunes
3. If there was a high wind velocity you would expect a small sand particle to get transported by
   a. suspension
   b. saltation
   c. creep
   d. pull
4. The motion that carries sand particles along in the wind in an arc shaped motion is called
   a. suspension
   b. saltation
   c. creep
   d. pull
5. When a dune is at a lake's edge, the portion of the coastal environment where sand movement is occurring by the force of water only is called the
   a. offshore
   b. foreshore
   c. backshore
   d. middleshore
6. The windward slope of a dune is often at an angle of about
   a. 0
   b. 10
   c. 30
   d. 60

7. Between 15,000 and 11,000 years ago the glaciers moved
   a. north
   b. south
   c. east
   d. west
8. The impressive dunes found at Sleeping Bear Dunes National Lakeshore are
   a. beach ridges
   b. parabolic dunes
   c. perched dunes
   d. stable dunes

Section 3 given to all test subjects

1. More permanent vegetation is found in the
   a. offshore
   b. foreshore
   c. backshore
   d. middleshore
2. One of the first plants to inhabit the backshore is
   a. cottonwood trees
   b. jack pine
   c. junipers
   d. beach grass
3. The Paw Paw tree is native to
   a. all of Michigan
   b. Michigan's Lower Peninsula
   c. Michigan's Upper Peninsula
   d. all of North America
4. Rounded pits where vegetation has been disturbed and removed are called
   a. horseshoes
   b. sand basins
   c. blowouts
   d. bowls
5. Until the recent effort to return gray wolves back to Michigan, the last known wolves were born in
   a. Traverse City
   b. The thumb
   c. Sleeping Bear National Lakeshore
   d. Pictured Rocks National Lakeshore
6. The introduced black pine species has negative effects on Michigan's dunes because
   a. the dunes tend to migrate faster
   b. the dunes should migrate but instead remain stationary
   c. black pines yield too many seeds and over-populate the rest of the dunes
   d. black pines provide too much shade

7. Normally, migratory birds return to the dunes around these months
   a. March and April
   b. May and June
   c. July and August
   d. September and October
8. In November and December snowshoe hares change fur color from
   a. gray to white
   b. white to gray
   c. black to white
   d. gray to black

Section 4 given to all the test subjects

1. People have lived in the Great Lakes region for the last
   a. 250,000 years
   b. 25,000 years
   c. 11,000 years
   d. 2,300 years
2. In the 1600s and 1700s people exploited ______ from the region
   a. Lumber and steel
   b. Furs and minerals
   c. Archeological remains
   d. Sand
3. At Rogers city, Michigan, one finds the world's largest
   a. Calcite mine
   b. sand dune
   c. petroleum reserve
   d. gypsum mine
4. In Michigan, manufacturing accounts for what percent of the state's gross annual production
   a. 10
   b. 27
   c. 54
   d. 72
5. Housing for both vacation and year-round residency is being built along
   a. Lake Michigan
   b. Lake Huron
   c. Lake Superior
   d. all four Great Lakes
6. In 1976 Michigan passed what act to provide for the study, protection, and management of the sand dunes
   a. Clean Water Act
   b. Coastal Zone Study Act
   c. Sand Dune Protection and Management Act
   d. Research and Endeavors Act

7. One of the most harmful recreation activities to the dunes is
   a. bathing
   b. camping
   c. hang gliding
   d. dune bugging
8. Talks are underway about exchanging land in the Sleeping Bear Dunes National Lakeshore because the land is
   a. not worth much
   b. all wetlands
   c. too big
   d. a place to build expensive houses

Attitude Adjectives

The list of words that appear one at a time along with the instructions are as follows:

1. Which do you think was the most **Interesting ?**

Paper Sections | Multimedia Sections | Both were | Neither were

2. Which do you think was the most **Fun ?**

Paper Sections | Multimedia Sections | Both were | Neither were

3. Which do you think was the most **Difficult?**

Paper Sections | Multimedia Sections | Both were | Neither were

4. Which do you think was the most **Confusing?**

Paper Sections | Multimedia Sections | Both were | Neither were

5. Which do you think was the most **Boring?**

Paper Sections | Multimedia Sections | Both were | Neither were

6. Which do you think was the most **Cool?**

Paper Sections | Multimedia Sections | Both were | Neither were

7. Which do you think was the most **Truthful?**

Paper Sections | Multimedia Sections | Both were | Neither were

Follow-up Questions

1. Did you like participating in this study?
2. What did you think about learning the lessons on the computer?
3. What did you think about learning the lessons from the paper sections?
4. Did you find the questions hard?
5. Do you think you learned more from the paper sections or the computer sections?
6. If you were to do this on another topic (other than coastal dunes) which type of lesson would you prefer to use, paper or computer?
7. Would you like to make any other comments or suggestions about the test or any of the materials you saw?

APPENDIX C

Student ID #	Question #	Student Group	Test Version	Media Type	Pres. Type	Seen Before	Correct Response	Response Time (sec.)
1	1	Y	1	mm	4.1	y	Y	3
1	2	Y	1	mm	2.1	y	Y	3
1	3	Y	1	mm	2.1	y	Y	3
1	4	Y	1	mm	2.2	n	Y	3
1	8	Y	1	mm	2.1	n	N	2
1	7	Y	1	mm	2.1	y	Y	1
1	9	Y	1	mm	3.1	y	Y	2
1	6	Y	1	mm	1.2	n	N	2
1	11	Y	1	text	1.1	y	N	4
1	12	Y	1	text	1.1	n	Y	2
1	17	Y	1	text	1.1	y	N	4
1	14	Y	1	text	2.1	n	Y	8
1	15	Y	1	text	2.1	y	N	3
1	16	Y	1	text	2.1	n	Y	3
1	13	Y	1	text	1.1	y	N	2
1	18	Y	1	text	2.1	n	N	4
1	21	Y	1	mm	3.1	y	Y	3
1	22	Y	1	mm	3.1	n	Y	3
1	23	Y	1	mm	1.1	y	N	2
1	24	Y	1	mm	2.1	n	N	4
1	26	Y	1	mm	2.1	n	Y	3
1	27	Y	1	mm	1.1	y	N	4
1	30	Y	1	mm	2.1	n	Y	4
1	29	Y	1	mm	2.1	y	Y	2
1	31	Y	1	text	1.1	y	N	7
1	32	Y	1	text	1.1	n	Y	5
1	36	Y	1	text	2.1	n	Y	2
1	35	Y	1	text	1.1	y	N	2
1	38	Y	1	text	1.1	n	Y	2
1	37	Y	1	text	1.1	y	N	4
1	40	Y	1	text	2.1	n	Y	6
1	39	Y	1	text	1.1	y	N	4
2	1	Y	1	mm	4.1	y	Y	2
2	2	Y	1	mm	3.1	n	Y	4
2	3	Y	1	mm	2.1	y	N	10
2	4	Y	1	mm	2.2	n	N	6
2	8	Y	1	mm	2.1	n	Y	7
2	7	Y	1	mm	2.1	y	Y	5
2	9	Y	1	mm	3.1	y	N	3
2	6	Y	1	mm	1.2	n	Y	3
2	11	Y	1	text	1.1	y	Y	9
2	12	Y	1	text	1.1	n	N	5
2	17	Y	1	text	1.1	y	N	6
2	14	Y	1	text	2.1	n	Y	6
2	15	Y	1	text	2.1	y	N	5
2	16	Y	1	text	2.1	n	N	24
2	13	Y	1	text	1.1	y	Y	11
2	18	Y	1	text	2.1	n	N	5
2	21	Y	1	mm	3.1	y	Y	2
2	22	Y	1	mm	3.1	n	N	4

2	23	Y	1	mm	1.1	y	N	12
2	24	Y	1	mm	2.1	n	N	4
2	26	Y	1	mm	2.1	n	Y	5
2	27	Y	1	mm	1.1	y	N	13
2	30	Y	1	mm	2.1	n	N	4
2	29	Y	1	mm	2.1	y	Y	8
2	31	Y	1	text	1.1	y	N	7
2	32	Y	1	text	1.1	n	N	5
2	36	Y	1	text	2.1	n	Y	4
2	35	Y	1	text	1.1	y	N	4
2	38	Y	1	text	1.1	n	Y	4
2	37	Y	1	text	1.1	y	Y	4
2	40	Y	1	text	2.1	n	Y	7
2	39	Y	1	text	1.1	y	N	16
3	1	Y	1	mm	4.1	y	Y	2
3	2	Y	1	mm	3.1	n	Y	2
3	3	Y	1	mm	2.1	y	Y	6
3	4	Y	1	mm	2.2	n	Y	2
3	8	Y	1	mm	2.1	n	Y	8
3	7	Y	1	mm	2.1	y	N	5
3	9	Y	1	mm	3.1	y	N	2
3	6	Y	1	mm	1.2	n	Y	2
3	11	Y	1	text	1.1	y	N	3
3	12	Y	1	text	1.1	n	N	7
3	17	Y	1	text	1.1	y	N	3
3	14	Y	1	text	2.1	n	N	5
3	15	Y	1	text	2.1	y	N	6
3	16	Y	1	text	2.1	n	Y	2
3	13	Y	1	text	1.1	y	N	2
3	18	Y	1	text	2.1	n	N	3
3	21	Y	1	mm	3.1	y	Y	3
3	22	Y	1	mm	3.1	n	Y	4
3	23	Y	1	mm	1.1	y	Y	3
3	24	Y	1	mm	2.1	n	Y	1
3	26	Y	1	mm	2.1	n	Y	6
3	27	Y	1	mm	1.1	y	Y	3
3	30	Y	1	mm	2.1	n	N	3
3	29	Y	1	mm	2.1	y	Y	2
3	31	Y	1	text	1.1	y	N	4
3	32	Y	1	text	1.1	n	N	6
3	36	Y	1	text	2.1	n	Y	3
3	35	Y	1	text	1.1	y	Y	2
3	38	Y	1	text	1.1	n	N	6
3	37	Y	1	text	1.1	y	N	1
3	40	Y	1	text	2.1	n	Y	2
3	39	Y	1	text	1.1	y	Y	6
4	1	Y	1	mm	4.1	y	Y	3
4	2	Y	1	mm	3.1	n	N	4
4	3	Y	1	mm	2.1	y	Y	3
4	4	Y	1	mm	2.2	n	Y	2
4	8	Y	1	mm	2.1	n	Y	5
4	7	Y	1	mm	2.1	y	N	6
4	9	Y	1	mm	3.1	y	N	2
4	6	Y	1	mm	1.2	n	N	10
4	11	Y	1	text	1.1	y	N	5
4	12	Y	1	text	1.1	n	N	31

4	17	Y	1	text	1.1	y	Y	2
4	14	Y	1	text	2.1	n	N	3
4	15	Y	1	text	2.1	y	N	13
4	16	Y	1	text	2.1	n	N	12
4	13	Y	1	text	1.1	y	N	8
4	18	Y	1	text	2.1	n	N	3
4	21	Y	1	mm	3.1	y	N	14
4	22	Y	1	mm	3.1	n	N	3
4	23	Y	1	mm	1.1	y	Y	4
4	24	Y	1	mm	2.1	n	Y	2
4	26	Y	1	mm	2.1	n	Y	2
4	27	Y	1	mm	1.1	y	N	3
4	30	Y	1	mm	2.1	n	N	2
4	29	Y	1	mm	2.1	y	Y	4
4	31	Y	1	text	1.1	y	Y	1
4	32	Y	1	text	1.1	n	N	14
4	36	Y	1	text	2.1	n	Y	2
4	35	Y	1	text	1.1	y	Y	13
4	38	Y	1	text	1.1	n	Y	2
4	37	Y	1	text	1.1	y	N	2
4	40	Y	1	text	2.1	n	Y	2
4	39	Y	1	text	1.1	y	Y	2
5	1	Y	1	mm	4.1	y	Y	2
5	2	Y	1	mm	3.1	n	N	5
5	3	Y	1	mm	2.1	y	Y	3
5	4	Y	1	mm	2.2	n	Y	3
5	8	Y	1	mm	2.1	n	N	3
5	7	Y	1	mm	2.1	y	N	1
5	9	Y	1	mm	3.1	y	N	1
5	6	Y	1	mm	1.2	n	N	5
5	11	Y	1	text	1.1	y	N	10
5	12	Y	1	text	1.1	n	N	2
5	17	Y	1	text	1.1	y	Y	2
5	14	Y	1	text	2.1	n	N	5
5	15	Y	1	text	2.1	y	N	9
5	16	Y	1	text	2.1	n	N	9
5	13	Y	1	text	1.1	y	Y	8
5	18	Y	1	text	2.1	n	N	1
5	21	Y	1	mm	3.1	y	N	3
5	22	Y	1	mm	3.1	n	N	6
5	23	Y	1	mm	1.1	y	N	4
5	24	Y	1	mm	2.1	n	N	20
5	26	Y	1	mm	2.1	n	Y	5
5	27	Y	1	mm	1.1	y	N	3
5	30	Y	1	mm	2.1	n	N	6
5	29	Y	1	mm	2.1	y	Y	2
5	31	Y	1	text	1.1	y	N	4
5	32	Y	1	text	1.1	n	Y	1
5	36	Y	1	text	2.1	n	N	1
5	35	Y	1	text	1.1	y	N	8
5	38	Y	1	text	1.1	n	N	2
5	37	Y	1	text	1.1	y	Y	8
5	40	Y	1	text	2.1	n	Y	3
5	39	Y	1	text	1.1	y	N	3
6	1	Y	1	mm	3.1	y	Y	2
6	2	Y	1	mm	2.1	n	Y	2

6	3	Y	1	mm	2.2	y	Y	3
6	4	Y	1	mm	2.1	n	Y	3
6	8	Y	1	mm	2.1	n	N	2
6	7	Y	1	mm	3.1	y	N	4
6	9	Y	1	mm	1.2	y	N	2
6	6	Y	1	mm	1.1	n	Y	16
6	11	Y	1	text	1.1	y	Y	7
6	12	Y	1	text	1.1	n	Y	2
6	17	Y	1	text	2.1	y	Y	4
6	14	Y	1	text	2.1	n	Y	3
6	15	Y	1	text	2.1	y	N	2
6	16	Y	1	text	1.1	n	N	7
6	13	Y	1	text	2.1	y	Y	2
6	18	Y	1	text	3.1	n	N	2
6	21	Y	1	mm	3.1	y	Y	1
6	22	Y	1	mm	1.1	n	N	2
6	23	Y	1	mm	2.1	y	Y	7
6	24	Y	1	mm	2.1	n	Y	1
6	26	Y	1	mm	1.1	n	Y	2
6	27	Y	1	mm	2.1	y	N	2
6	30	Y	1	mm	2.1	n	N	5
6	29	Y	1	mm	1.1	y	Y	4
6	31	Y	1	text	1.1	y	N	12
6	32	Y	1	text	2.1	n	Y	2
6	36	Y	1	text	1.1	n	Y	2
6	35	Y	1	text	1.1	y	Y	2
6	38	Y	1	text	1.1	n	N	29
6	37	Y	1	text	2.1	y	N	4
6	40	Y	1	text	1.1	n	Y	3
6	39	Y	1	text	2.1	y	Y	4
7	1	Y	1	mm	4.1	y	Y	3
7	2	Y	1	mm	3.1	n	Y	11
7	3	Y	1	mm	2.1	y	Y	3
7	4	Y	1	mm	2.2	n	N	3
7	8	Y	1	mm	2.1	n	N	3
7	7	Y	1	mm	2.1	y	Y	1
7	9	Y	1	mm	3.1	y	N	4
7	6	Y	1	mm	1.2	n	N	9
7	11	Y	1	text	1.1	y	N	12
7	12	Y	1	text	1.1	n	N	12
7	17	Y	1	text	1.1	y	N	12
7	14	Y	1	text	2.1	n	N	16
7	15	Y	1	text	2.1	y	N	21
7	16	Y	1	text	2.1	n	Y	20
7	13	Y	1	text	1.1	y	N	1
7	18	Y	1	text	2.1	n	N	1
7	21	Y	1	mm	3.1	y	Y	2
7	22	Y	1	mm	3.1	n	N	11
7	23	Y	1	mm	1.1	y	N	3
7	24	Y	1	mm	2.1	n	Y	3
7	26	Y	1	mm	2.1	n	N	6
7	27	Y	1	mm	1.1	y	N	3
7	30	Y	1	mm	2.1	n	N	4
7	29	Y	1	mm	2.1	y	Y	3
7	31	Y	1	text	1.1	y	N	6
7	32	Y	1	text	1.1	n	N	8

7	36	Y	1	text	2.1	n	N	14
7	35	Y	1	text	1.1	y	Y	6
7	38	Y	1	text	1.1	n	Y	4
7	37	Y	1	text	1.1	y	Y	10
7	40	Y	1	text	2.1	n	Y	1
7	39	Y	1	text	1.1	y	N	14
8	1	Y	1	mm	4.1	y	Y	5
8	2	Y	1	mm	3.1	n	Y	20
8	3	Y	1	mm	2.1	y	Y	12
8	4	Y	1	mm	2.2	n	N	11
8	8	Y	1	mm	2.1	n	N	14
8	7	Y	1	mm	2.1	y	Y	4
8	9	Y	1	mm	3.1	y	N	9
8	6	Y	1	mm	1.2	n	Y	11
8	11	Y	1	text	1.1	y	N	12
8	12	Y	1	text	1.1	n	N	8
8	17	Y	1	text	1.1	y	N	12
8	14	Y	1	text	2.1	n	Y	6
8	15	Y	1	text	2.1	y	N	7
8	16	Y	1	text	2.1	n	Y	19
8	13	Y	1	text	1.1	y	Y	9
8	18	Y	1	text	2.1	n	N	10
8	21	Y	1	mm	3.1	y	Y	6
8	22	Y	1	mm	3.1	n	N	7
8	23	Y	1	mm	1.1	y	Y	11
8	24	Y	1	mm	2.1	n	Y	6
8	26	Y	1	mm	2.1	n	N	8
8	27	Y	1	mm	1.1	y	N	5
8	30	Y	1	mm	2.1	n	Y	2
8	29	Y	1	mm	2.1	y	Y	8
8	31	Y	1	text	1.1	y	N	6
8	32	Y	1	text	1.1	n	Y	7
8	36	Y	1	text	2.1	n	N	7
8	35	Y	1	text	1.1	y	N	4
8	38	Y	1	text	1.1	n	N	4
8	37	Y	1	text	1.1	y	N	3
8	40	Y	1	text	2.1	n	Y	4
8	39	Y	1	text	1.1	y	N	2
9	1	Y	1	mm	4.1	y	Y	3
9	2	Y	1	mm	3.1	n	Y	2
9	3	Y	1	mm	2.1	y	Y	2
9	4	Y	1	mm	2.2	n	Y	4
9	8	Y	1	mm	2.1	n	N	2
9	7	Y	1	mm	2.1	y	Y	2
9	9	Y	1	mm	3.1	y	N	2
9	6	Y	1	mm	1.2	n	Y	23
9	11	Y	1	text	1.1	y	Y	3
9	12	Y	1	text	1.1	n	Y	4
9	17	Y	1	text	1.1	y	Y	2
9	14	Y	1	text	2.1	n	Y	11
9	15	Y	1	text	2.1	y	N	6
9	16	Y	1	text	2.1	n	N	4
9	13	Y	1	text	1.1	y	N	3
9	18	Y	1	text	2.1	n	N	2
9	21	Y	1	mm	3.1	y	Y	3
9	22	Y	1	mm	3.1	n	N	2

9	23	Y	1	mm	1.1	y	N	4
9	24	Y	1	mm	2.1	n	Y	4
9	26	Y	1	mm	2.1	n	N	2
9	27	Y	1	mm	1.1	y	Y	3
9	30	Y	1	mm	2.1	n	Y	2
9	29	Y	1	mm	2.1	y	N	12
9	31	Y	1	text	1.1	y	Y	3
9	32	Y	1	text	1.1	n	Y	6
9	36	Y	1	text	2.1	n	N	2
9	35	Y	1	text	1.1	y	N	5
9	38	Y	1	text	1.1	n	Y	4
9	37	Y	1	text	1.1	y	Y	4
9	40	Y	1	text	2.1	n	N	3
9	39	Y	1	text	1.1	y	N	2
10	1	Y	1	mm	4.1	y	Y	4
10	2	Y	1	mm	3.1	n	Y	6
10	3	Y	1	mm	2.1	y	N	3
10	4	Y	1	mm	2.2	n	N	4
10	8	Y	1	mm	2.1	n	N	6
10	7	Y	1	mm	2.1	y	N	8
10	9	Y	1	mm	3.1	y	N	3
10	6	Y	1	mm	1.2	n	Y	3
10	11	Y	1	text	1.1	y	N	6
10	12	Y	1	text	1.1	n	N	4
10	17	Y	1	text	1.1	y	N	2
10	14	Y	1	text	2.1	n	N	11
10	15	Y	1	text	2.1	y	N	11
10	16	Y	1	text	2.1	n	N	5
10	13	Y	1	text	1.1	y	N	5
10	18	Y	1	text	2.1	n	N	6
10	21	Y	1	mm	3.1	y	N	14
10	22	Y	1	mm	3.1	n	N	4
10	23	Y	1	mm	1.1	y	Y	14
10	24	Y	1	mm	2.1	n	N	15
10	26	Y	1	mm	2.1	n	N	12
10	27	Y	1	mm	1.1	y	N	13
10	30	Y	1	mm	2.1	n	Y	57
10	29	Y	1	mm	2.1	y	Y	14
10	31	Y	1	text	1.1	y	N	11
10	32	Y	1	text	1.1	n	Y	4
10	36	Y	1	text	2.1	n	N	9
10	35	Y	1	text	1.1	y	N	13
10	38	Y	1	text	1.1	n	Y	10
10	37	Y	1	text	1.1	y	Y	11
10	40	Y	1	text	2.1	n	N	8
10	39	Y	1	text	1.1	y	N	10
11	1	Y	1	mm	4.1	y	Y	2
11	2	Y	1	mm	3.1	n	Y	4
11	3	Y	1	mm	2.1	y	N	5
11	4	Y	1	mm	2.2	n	Y	5
11	8	Y	1	mm	2.1	n	Y	7
11	7	Y	1	mm	2.1	y	Y	5
11	9	Y	1	mm	3.1	y	N	3
11	6	Y	1	mm	1.2	n	Y	3
11	11	Y	1	text	1.1	y	Y	8
11	12	Y	1	text	1.1	n	N	5

11	17	Y	1	text	1.1	y	Y	5
11	14	Y	1	text	2.1	n	Y	6
11	15	Y	1	text	2.1	y	N	5
11	16	Y	1	text	2.1	n	N	14
11	13	Y	1	text	1.1	y	Y	7
11	18	Y	1	text	2.1	n	N	4
11	21	Y	1	mm	3.1	y	Y	2
11	22	Y	1	mm	3.1	n	Y	3
11	23	Y	1	mm	1.1	y	N	10
11	24	Y	1	mm	2.1	n	N	2
11	26	Y	1	mm	2.1	n	Y	2
11	27	Y	1	mm	1.1	y	Y	13
11	30	Y	1	mm	2.1	n	N	4
11	29	Y	1	mm	2.1	y	Y	8
11	31	Y	1	text	1.1	y	N	2
11	32	Y	1	text	1.1	n	N	5
11	36	Y	1	text	2.1	n	N	2
11	35	Y	1	text	1.1	y	N	4
11	38	Y	1	text	1.1	n	Y	4
11	37	Y	1	text	1.1	y	N	2
11	40	Y	1	text	2.1	n	Y	7
11	39	Y	1	text	1.1	y	N	23
12	1	Y	1	mm	4.1	y	Y	2
12	2	Y	1	mm	3.1	n	Y	5
12	3	Y	1	mm	2.1	y	Y	3
12	4	Y	1	mm	2.2	n	Y	3
12	8	Y	1	mm	2.1	n	Y	3
12	7	Y	1	mm	2.1	y	Y	1
12	9	Y	1	mm	3.1	y	N	1
12	6	Y	1	mm	1.2	n	Y	5
12	11	Y	1	text	1.1	y	Y	10
12	12	Y	1	text	1.1	n	N	2
12	17	Y	1	text	1.1	y	N	2
12	14	Y	1	text	2.1	n	N	5
12	15	Y	1	text	2.1	y	N	9
12	16	Y	1	text	2.1	n	N	9
12	13	Y	1	text	1.1	y	Y	8
12	18	Y	1	text	2.1	n	N	1
12	21	Y	1	mm	3.1	y	Y	3
12	22	Y	1	mm	3.1	n	N	6
12	23	Y	1	mm	1.1	y	N	4
12	24	Y	1	mm	2.1	n	N	20
12	26	Y	1	mm	2.1	n	N	5
12	27	Y	1	mm	1.1	y	N	3
12	30	Y	1	mm	2.1	n	N	6
12	29	Y	1	mm	2.1	y	Y	2
12	31	Y	1	text	1.1	y	N	4
12	32	Y	1	text	1.1	n	Y	1
12	36	Y	1	text	2.1	n	N	1
12	35	Y	1	text	1.1	y	N	8
12	38	Y	1	text	1.1	n	N	2
12	37	Y	1	text	1.1	y	Y	8
12	40	Y	1	text	2.1	n	Y	3
12	39	Y	1	text	1.1	y	N	3
13	1	N	1	mm	4.1	y	Y	2
13	2	N	1	mm	3.1	n	Y	2

13	3	N	1	mm	2.1	y	Y	3
13	4	N	1	mm	2.2	n	Y	2
13	8	N	1	mm	2.1	n	N	2
13	7	N	1	mm	2.1	y	Y	2
13	9	N	1	mm	3.1	y	N	1
13	6	N	1	mm	1.2	n	N	1
13	11	N	1	text	1.1	y	N	3
13	12	N	1	text	1.1	n	N	3
13	17	N	1	text	1.1	y	N	4
13	14	N	1	text	2.1	n	N	5
13	15	N	1	text	2.1	y	N	5
13	16	N	1	text	2.1	n	Y	3
13	13	N	1	text	1.1	y	Y	3
13	18	N	1	text	2.1	n	N	2
13	21	N	1	mm	3.1	y	Y	2
13	22	N	1	mm	3.1	n	Y	3
13	23	N	1	mm	1.1	y	N	5
13	24	N	1	mm	2.1	n	N	3
13	26	N	1	mm	2.1	n	Y	3
13	27	N	1	mm	1.1	y	N	2
13	30	N	1	mm	2.1	n	Y	4
13	29	N	1	mm	2.1	y	Y	2
13	31	N	1	text	1.1	y	N	4
13	32	N	1	text	1.1	n	N	3
13	36	N	1	text	2.1	n	Y	2
13	35	N	1	text	1.1	y	N	2
13	38	N	1	text	1.1	n	N	2
13	37	N	1	text	1.1	y	Y	4
13	40	N	1	text	2.1	n	Y	6
13	39	N	1	text	1.1	y	Y	4
14	1	N	1	mm	4.1	y	Y	2
14	2	N	1	mm	3.1	n	Y	3
14	3	N	1	mm	2.1	y	Y	3
14	4	N	1	mm	2.2	n	N	6
14	8	N	1	mm	2.1	n	Y	7
14	7	N	1	mm	2.1	y	Y	5
14	9	N	1	mm	3.1	y	Y	5
14	6	N	1	mm	1.2	n	N	3
14	11	N	1	text	1.1	y	Y	9
14	12	N	1	text	1.1	n	N	3
14	17	N	1	text	1.1	y	N	6
14	14	N	1	text	2.1	n	Y	6
14	15	N	1	text	2.1	y	N	5
14	16	N	1	text	2.1	n	N	4
14	13	N	1	text	1.1	y	Y	3
14	18	N	1	text	2.1	n	N	3
14	21	N	1	mm	3.1	y	Y	2
14	22	N	1	mm	3.1	n	Y	4
14	23	N	1	mm	1.1	y	N	12
14	24	N	1	mm	2.1	n	N	5
14	26	N	1	mm	2.1	n	Y	5
14	27	N	1	mm	1.1	y	N	9
14	30	N	1	mm	2.1	n	N	3
14	29	N	1	mm	2.1	y	Y	8
14	31	N	1	text	1.1	y	N	4
14	32	N	1	text	1.1	n	N	5

14	36	N	1	text	2.1	n	N	4
14	35	N	1	text	1.1	y	N	5
14	38	N	1	text	1.1	n	N	4
14	37	N	1	text	1.1	y	N	27
14	40	N	1	text	2.1	n	Y	14
14	39	N	1	text	1.1	y	N	16
15	1	N	1	mm	4.1	y	Y	6
15	2	N	1	mm	3.1	n	Y	3
15	3	N	1	mm	2.1	y	N	6
15	4	N	1	mm	2.2	n	N	3
15	8	N	1	mm	2.1	n	N	5
15	7	N	1	mm	2.1	y	N	7
15	9	N	1	mm	3.1	y	Y	4
15	6	N	1	mm	1.2	n	Y	4
15	11	N	1	text	1.1	y	N	5
15	12	N	1	text	1.1	n	N	2
15	17	N	1	text	1.1	y	N	5
15	14	N	1	text	2.1	n	N	3
15	15	N	1	text	2.1	y	N	2
15	16	N	1	text	2.1	n	N	4
15	13	N	1	text	1.1	y	N	23
15	18	N	1	text	2.1	n	N	2
15	21	N	1	mm	3.1	y	Y	5
15	22	N	1	mm	3.1	n	Y	4
15	23	N	1	mm	1.1	y	N	5
15	24	N	1	mm	2.1	n	Y	6
15	26	N	1	mm	2.1	n	Y	7
15	27	N	1	mm	1.1	y	N	7
15	30	N	1	mm	2.1	n	N	8
15	29	N	1	mm	2.1	y	Y	4
15	31	N	1	text	1.1	y	N	4
15	32	N	1	text	1.1	n	N	6
15	36	N	1	text	2.1	n	Y	7
15	35	N	1	text	1.1	y	N	5
15	38	N	1	text	1.1	n	N	4
15	37	N	1	text	1.1	y	N	3
15	40	N	1	text	2.1	n	Y	2
15	39	N	1	text	1.1	y	N	5
16	1	N	1	mm	4.1	y	Y	8
16	2	N	1	mm	3.1	n	Y	5
16	3	N	1	mm	2.1	y	Y	8
16	4	N	1	mm	2.2	n	Y	5
16	8	N	1	mm	2.1	n	Y	4
16	7	N	1	mm	2.1	y	N	5
16	9	N	1	mm	3.1	y	Y	7
16	6	N	1	mm	1.2	n	N	5
16	11	N	1	text	1.1	y	N	2
16	12	N	1	text	1.1	n	N	8
16	17	N	1	text	1.1	y	N	9
16	14	N	1	text	2.1	n	Y	6
16	15	N	1	text	2.1	y	Y	8
16	16	N	1	text	2.1	n	Y	6
16	13	N	1	text	1.1	y	N	5
16	18	N	1	text	2.1	n	N	17
16	21	N	1	mm	3.1	y	Y	5
16	22	N	1	mm	3.1	n	Y	4

16	23	N	1	mm	1.1	y	N	9
16	24	N	1	mm	2.1	n	Y	7
16	26	N	1	mm	2.1	n	Y	4
16	27	N	1	mm	1.1	y	N	2
16	30	N	1	mm	2.1	n	N	2
16	29	N	1	mm	2.1	y	Y	3
16	31	N	1	text	1.1	y	N	3
16	32	N	1	text	1.1	n	N	3
16	36	N	1	text	2.1	n	Y	3
16	35	N	1	text	1.1	y	N	1
16	38	N	1	text	1.1	n	Y	3
16	37	N	1	text	1.1	y	N	3
16	40	N	1	text	2.1	n	Y	2
16	39	N	1	text	1.1	y	N	4
17	1	N	1	mm	4.1	y	Y	8
17	2	N	1	mm	3.1	n	N	5
17	3	N	1	mm	2.1	y	Y	15
17	4	N	1	mm	2.2	n	Y	6
17	8	N	1	mm	2.1	n	Y	3
17	7	N	1	mm	2.1	y	N	6
17	9	N	1	mm	3.1	y	Y	17
17	6	N	1	mm	1.2	n	N	7
17	11	N	1	text	1.1	y	N	6
17	12	N	1	text	1.1	n	N	8
17	17	N	1	text	1.1	y	Y	4
17	14	N	1	text	2.1	n	N	3
17	15	N	1	text	2.1	y	N	5
17	16	N	1	text	2.1	n	N	4
17	13	N	1	text	1.1	y	Y	6
17	18	N	1	text	2.1	n	N	5
17	21	N	1	mm	3.1	y	N	3
17	22	N	1	mm	3.1	n	N	2
17	23	N	1	mm	1.1	y	N	5
17	24	N	1	mm	2.1	n	N	5
17	26	N	1	mm	2.1	n	Y	3
17	27	N	1	mm	1.1	y	N	6
17	30	N	1	mm	2.1	n	N	3
17	29	N	1	mm	2.1	y	N	6
17	31	N	1	text	1.1	y	N	3
17	32	N	1	text	1.1	n	Y	6
17	36	N	1	text	2.1	n	N	3
17	35	N	1	text	1.1	y	N	7
17	38	N	1	text	1.1	n	N	3
17	37	N	1	text	1.1	y	Y	7
17	40	N	1	text	2.1	n	Y	2
17	39	N	1	text	1.1	y	N	4
18	1	N	1	mm	4.1	y	Y	2
18	2	N	1	mm	3.1	n	Y	8
18	3	N	1	mm	2.1	y	Y	4
18	4	N	1	mm	2.2	n	Y	5
18	8	N	1	mm	2.1	n	N	4
18	7	N	1	mm	2.1	y	N	6
18	9	N	1	mm	3.1	y	Y	3
18	6	N	1	mm	1.2	n	Y	8
18	11	N	1	text	1.1	y	Y	2
18	12	N	1	text	1.1	n	Y	2

18	17	N	1	text	1.1	y	Y	5
18	14	N	1	text	2.1	n	Y	4
18	15	N	1	text	2.1	y	N	7
18	16	N	1	text	2.1	n	N	4
18	13	N	1	text	1.1	y	N	14
18	18	N	1	text	2.1	n	N	3
18	21	N	1	mm	3.1	y	Y	5
18	22	N	1	mm	3.1	n	N	2
18	23	N	1	mm	1.1	y	Y	29
18	24	N	1	mm	2.1	n	Y	4
18	26	N	1	mm	2.1	n	Y	3
18	27	N	1	mm	1.1	y	N	2
18	30	N	1	mm	2.1	n	N	1
18	29	N	1	mm	2.1	y	Y	4
18	31	N	1	text	1.1	y	N	2
18	32	N	1	text	1.1	n	Y	5
18	36	N	1	text	2.1	n	Y	3
18	35	N	1	text	1.1	y	N	7
18	38	N	1	text	1.1	n	N	4
18	37	N	1	text	1.1	y	N	2
18	40	N	1	text	2.1	n	Y	6
18	39	N	1	text	1.1	y	N	5
19	1	N	1	mm	4.1	y	Y	5
19	2	N	1	mm	3.1	n	Y	3
19	3	N	1	mm	2.1	y	Y	2
19	4	N	1	mm	2.2	n	N	2
19	8	N	1	mm	2.1	n	N	11
19	7	N	1	mm	2.1	y	Y	4
19	9	N	1	mm	3.1	y	Y	6
19	6	N	1	mm	1.2	n	N	4
19	11	N	1	text	1.1	y	N	7
19	12	N	1	text	1.1	n	N	4
19	17	N	1	text	1.1	y	N	4
19	14	N	1	text	2.1	n	N	2
19	15	N	1	text	2.1	y	N	1
19	16	N	1	text	2.1	n	Y	3
19	13	N	1	text	1.1	y	N	6
19	18	N	1	text	2.1	n	N	3
19	21	N	1	mm	3.1	y	Y	2
19	22	N	1	mm	3.1	n	Y	1
19	23	N	1	mm	1.1	y	N	3
19	24	N	1	mm	2.1	n	N	18
19	26	N	1	mm	2.1	n	N	3
19	27	N	1	mm	1.1	y	N	2
19	30	N	1	mm	2.1	n	N	8
19	29	N	1	mm	2.1	y	N	6
19	31	N	1	text	1.1	y	N	5
19	32	N	1	text	1.1	n	N	4
19	36	N	1	text	2.1	n	N	4
19	35	N	1	text	1.1	y	Y	3
19	38	N	1	text	1.1	n	Y	2
19	37	N	1	text	1.1	y	N	6
19	40	N	1	text	2.1	n	Y	3
19	39	N	1	text	1.1	y	N	2
20	1	N	1	mm	4.1	y	Y	5
20	2	N	1	mm	3.1	n	Y	3

20	3	N	1	mm	2.1	y	N	3
20	4	N	1	mm	2.2	n	N	2
20	8	N	1	mm	2.1	n	N	2
20	7	N	1	mm	2.1	y	Y	5
20	9	N	1	mm	3.1	y	Y	2
20	6	N	1	mm	1.2	n	Y	6
20	11	N	1	text	1.1	y	N	16
20	12	N	1	text	1.1	n	N	3
20	17	N	1	text	1.1	y	N	5
20	14	N	1	text	2.1	n	Y	7
20	15	N	1	text	2.1	y	N	9
20	16	N	1	text	2.1	n	Y	7
20	13	N	1	text	1.1	y	Y	5
20	18	N	1	text	2.1	n	N	5
20	21	N	1	mm	3.1	y	Y	4
20	22	N	1	mm	3.1	n	Y	3
20	23	N	1	mm	1.1	y	Y	5
20	24	N	1	mm	2.1	n	Y	4
20	26	N	1	mm	2.1	n	Y	7
20	27	N	1	mm	1.1	y	N	3
20	30	N	1	mm	2.1	n	Y	7
20	29	N	1	mm	2.1	y	Y	8
20	31	N	1	text	1.1	y	N	5
20	32	N	1	text	1.1	n	N	7
20	36	N	1	text	2.1	n	N	5
20	35	N	1	text	1.1	y	N	4
20	38	N	1	text	1.1	n	N	4
20	37	N	1	text	1.1	y	N	3
20	40	N	1	text	2.1	n	Y	4
20	39	N	1	text	1.1	y	N	2
21	1	N	1	mm	4.1	y	Y	9
21	2	N	1	mm	3.1	n	Y	5
21	3	N	1	mm	2.1	y	Y	8
21	4	N	1	mm	2.2	n	Y	4
21	8	N	1	mm	2.1	n	N	3
21	7	N	1	mm	2.1	y	Y	3
21	9	N	1	mm	3.1	y	Y	3
21	6	N	1	mm	1.2	n	Y	4
21	11	N	1	text	1.1	y	Y	2
21	12	N	1	text	1.1	n	Y	2
21	17	N	1	text	1.1	y	Y	2
21	14	N	1	text	2.1	n	Y	11
21	15	N	1	text	2.1	y	N	6
21	16	N	1	text	2.1	n	N	3
21	13	N	1	text	1.1	y	N	3
21	18	N	1	text	2.1	n	N	2
21	21	N	1	mm	3.1	y	Y	3
21	22	N	1	mm	3.1	n	Y	2
21	23	N	1	mm	1.1	y	N	4
21	24	N	1	mm	2.1	n	Y	3
21	26	N	1	mm	2.1	n	N	2
21	27	N	1	mm	1.1	y	N	3
21	30	N	1	mm	2.1	n	N	3
21	29	N	1	mm	2.1	y	N	2
21	31	N	1	text	1.1	y	N	3
21	32	N	1	text	1.1	n	Y	3

21	36	N	1	text	2.1	n	N	2
21	35	N	1	text	1.1	y	N	5
21	38	N	1	text	1.1	n	Y	4
21	37	N	1	text	1.1	y	N	6
21	40	N	1	text	2.1	n	N	3
21	39	N	1	text	1.1	y	N	2
22	1	N	1	mm	4.1	y	Y	4
22	2	N	1	mm	3.1	n	Y	4
22	3	N	1	mm	2.1	y	N	3
22	4	N	1	mm	2.2	n	N	3
22	8	N	1	mm	2.1	n	N	2
22	7	N	1	mm	2.1	y	N	5
22	9	N	1	mm	3.1	y	Y	3
22	6	N	1	mm	1.2	n	Y	5
22	11	N	1	text	1.1	y	N	3
22	12	N	1	text	1.1	n	N	6
22	17	N	1	text	1.1	y	N	4
22	14	N	1	text	2.1	n	N	4
22	15	N	1	text	2.1	y	N	4
22	16	N	1	text	2.1	n	N	6
22	13	N	1	text	1.1	y	N	3
22	18	N	1	text	2.1	n	N	2
22	21	N	1	mm	3.1	y	Y	5
22	22	N	1	mm	3.1	n	N	4
22	23	N	1	mm	1.1	y	Y	6
22	24	N	1	mm	2.1	n	N	15
22	26	N	1	mm	2.1	n	N	3
22	27	N	1	mm	1.1	y	N	3
22	30	N	1	mm	2.1	n	Y	5
22	29	N	1	mm	2.1	y	N	14
22	31	N	1	text	1.1	y	N	11
22	32	N	1	text	1.1	n	Y	5
22	36	N	1	text	2.1	n	N	3
22	35	N	1	text	1.1	y	N	6
22	38	N	1	text	1.1	n	Y	4
22	37	N	1	text	1.1	y	Y	4
22	40	N	1	text	2.1	n	N	3
22	39	N	1	text	1.1	y	N	7
23	1	N	1	mm	4.1	y	Y	4
23	2	N	1	mm	3.1	n	Y	6
23	3	N	1	mm	2.1	y	N	32
23	4	N	1	mm	2.2	n	Y	6
23	8	N	1	mm	2.1	n	Y	7
23	7	N	1	mm	2.1	y	Y	3
23	9	N	1	mm	3.1	y	Y	5
23	6	N	1	mm	1.2	n	Y	6
23	11	N	1	text	1.1	y	N	3
23	12	N	1	text	1.1	n	N	9
23	17	N	1	text	1.1	y	Y	7
23	14	N	1	text	2.1	n	Y	8
23	15	N	1	text	2.1	y	N	6
23	16	N	1	text	2.1	n	N	5
23	13	N	1	text	1.1	y	N	3
23	18	N	1	text	2.1	n	N	3
23	21	N	1	mm	3.1	y	Y	5
23	22	N	1	mm	3.1	n	Y	3

23	23	N	1	mm	1.1	y	N	6
23	24	N	1	mm	2.1	n	N	2
23	26	N	1	mm	2.1	n	Y	2
23	27	N	1	mm	1.1	y	Y	26
23	30	N	1	mm	2.1	n	N	4
23	29	N	1	mm	2.1	y	Y	5
23	31	N	1	text	1.1	y	N	2
23	32	N	1	text	1.1	n	N	5
23	36	N	1	text	2.1	n	N	2
23	35	N	1	text	1.1	y	N	4
23	38	N	1	text	1.1	n	Y	3
23	37	N	1	text	1.1	y	N	2
23	40	N	1	text	2.1	n	Y	7
23	39	N	1	text	1.1	y	N	5
24	1	Y	2	text	1.1	n	N	7
24	2	Y	2	text	1.1	y	N	4
24	3	Y	2	text	2.1	n	N	3
24	4	Y	2	text	1.1	y	N	15
24	8	Y	2	text	2.1	y	Y	8
24	7	Y	2	text	2.1	n	Y	8
24	9	Y	2	text	2.1	n	Y	7
24	6	Y	2	text	1.2	y	N	2
24	11	Y	2	mm	1.4	n	N	9
24	12	Y	2	mm	3.3	y	N	2
24	17	Y	2	mm	3.2	y	Y	6
24	14	Y	2	mm	3.3	y	Y	8
24	15	Y	2	mm	2.3	n	N	3
24	16	Y	2	mm	3.1	y	Y	3
24	13	Y	2	mm	1.4	n	N	3
24	18	Y	2	mm	3.3	n	N	4
24	21	Y	2	text	2.1	n	Y	3
24	22	Y	2	text	2.1	y	Y	7
24	23	Y	2	text	1.1	n	N	2
24	24	Y	2	text	2.1	y	N	4
24	26	Y	2	text	2.1	y	Y	4
24	27	Y	2	text	1.1	n	N	4
24	30	Y	2	text	2.1	y	N	4
24	29	Y	2	text	2.1	n	N	2
24	31	Y	2	mm	1.1	n	N	7
24	32	Y	2	mm	2.2	y	N	8
24	36	Y	2	mm	3.1	y	N	2
24	35	Y	2	mm	1.1	n	N	2
24	38	Y	2	mm	3.1	y	Y	2
24	37	Y	2	mm	1.1	n	N	4
24	40	Y	2	mm	3.1	y	N	6
24	39	Y	2	mm	4.1	n	Y	4
25	1	Y	2	text	1.1	n	N	3
25	2	Y	2	text	1.1	y	N	4
25	3	Y	2	text	2.1	n	N	3
25	4	Y	2	text	1.1	y	Y	5
25	8	Y	2	text	2.1	y	Y	2
25	7	Y	2	text	2.1	n	Y	1
25	9	Y	2	text	2.1	n	Y	4
25	6	Y	2	text	1.2	y	N	2
25	11	Y	2	mm	1.4	n	N	4
25	12	Y	2	mm	3.3	y	Y	2

25	17	Y	2	mm	3.2	y	Y	4
25	14	Y	2	mm	3.3	y	Y	8
25	15	Y	2	mm	2.3	n	N	3
25	16	Y	2	mm	3.1	y	N	3
25	13	Y	2	mm	1.4	n	N	8
25	18	Y	2	mm	3.3	n	Y	4
25	21	Y	2	text	2.1	n	Y	3
25	22	Y	2	text	2.1	y	Y	5
25	23	Y	2	text	1.1	n	N	2
25	24	Y	2	text	2.1	y	N	4
25	26	Y	2	text	2.1	y	N	7
25	27	Y	2	text	1.1	n	N	4
25	30	Y	2	text	2.1	y	N	4
25	29	Y	2	text	2.1	n	Y	5
25	31	Y	2	mm	1.1	n	N	7
25	32	Y	2	mm	2.2	y	N	5
25	36	Y	2	mm	3.1	y	N	8
25	35	Y	2	mm	1.1	n	N	2
25	38	Y	2	mm	3.1	y	Y	2
25	37	Y	2	mm	1.1	n	N	5
25	40	Y	2	mm	3.1	y	Y	6
25	39	Y	2	mm	4.1	n	Y	4
26	1	Y	2	text	1.1	n	Y	6
26	2	Y	2	text	1.1	y	N	4
26	3	Y	2	text	2.1	n	N	8
26	4	Y	2	text	1.1	y	N	6
26	8	Y	2	text	2.1	y	Y	8
26	7	Y	2	text	2.1	n	Y	1
26	9	Y	2	text	2.1	n	Y	2
26	6	Y	2	text	1.2	y	N	2
26	11	Y	2	mm	1.4	n	Y	5
26	12	Y	2	mm	3.3	y	Y	2
26	17	Y	2	mm	3.2	y	Y	4
26	14	Y	2	mm	3.3	y	Y	6
26	15	Y	2	mm	2.3	n	N	3
26	16	Y	2	mm	3.1	y	N	5
26	13	Y	2	mm	1.4	n	N	6
26	18	Y	2	mm	3.3	n	Y	4
26	21	Y	2	text	2.1	n	Y	3
26	22	Y	2	text	2.1	y	Y	4
26	23	Y	2	text	1.1	n	N	2
26	24	Y	2	text	2.1	y	N	4
26	26	Y	2	text	2.1	y	N	7
26	27	Y	2	text	1.1	n	Y	4
26	30	Y	2	text	2.1	y	N	4
26	29	Y	2	text	2.1	n	Y	5
26	31	Y	2	mm	1.1	n	N	7
26	32	Y	2	mm	2.2	y	Y	5
26	36	Y	2	mm	3.1	y	Y	7
26	35	Y	2	mm	1.1	n	N	2
26	38	Y	2	mm	3.1	y	Y	2
26	37	Y	2	mm	1.1	n	N	6
26	40	Y	2	mm	3.1	y	Y	6
26	39	Y	2	mm	4.1	n	Y	4
27	1	Y	2	text	1.1	n	Y	3
27	2	Y	2	text	1.1	y	N	4

27	3	Y	2	text	2.1	n	N	4
27	4	Y	2	text	1.1	y	Y	3
27	8	Y	2	text	2.1	y	Y	2
27	7	Y	2	text	2.1	n	N	8
27	9	Y	2	text	2.1	n	Y	2
27	6	Y	2	text	1.2	y	N	2
27	11	Y	2	mm	1.4	n	N	5
27	12	Y	2	mm	3.3	y	Y	2
27	17	Y	2	mm	3.2	y	Y	4
27	14	Y	2	mm	3.3	y	Y	7
27	15	Y	2	mm	2.3	n	Y	3
27	16	Y	2	mm	3.1	y	Y	6
27	13	Y	2	mm	1.4	n	N	2
27	18	Y	2	mm	3.3	n	Y	4
27	21	Y	2	text	2.1	n	Y	3
27	22	Y	2	text	2.1	y	Y	9
27	23	Y	2	text	1.1	n	N	16
27	24	Y	2	text	2.1	y	N	4
27	26	Y	2	text	2.1	y	N	4
27	27	Y	2	text	1.1	n	N	6
27	30	Y	2	text	2.1	y	N	4
27	29	Y	2	text	2.1	n	Y	16
27	31	Y	2	mm	1.1	n	N	17
27	32	Y	2	mm	2.2	y	N	5
27	36	Y	2	mm	3.1	y	Y	3
27	35	Y	2	mm	1.1	n	N	2
27	38	Y	2	mm	3.1	y	N	2
27	37	Y	2	mm	1.1	n	N	7
27	40	Y	2	mm	3.1	y	Y	6
27	39	Y	2	mm	4.1	n	Y	1
28	1	Y	2	text	1.1	n	Y	7
28	2	Y	2	text	1.1	y	Y	9
28	3	Y	2	text	2.1	n	N	7
28	4	Y	2	text	1.1	y	Y	13
28	8	Y	2	text	2.1	y	Y	8
28	7	Y	2	text	2.1	n	Y	4
28	9	Y	2	text	2.1	n	Y	8
28	6	Y	2	text	1.2	y	N	16
28	11	Y	2	mm	1.4	n	N	7
28	12	Y	2	mm	3.3	y	Y	2
28	17	Y	2	mm	3.2	y	Y	4
28	14	Y	2	mm	3.3	y	Y	4
28	15	Y	2	mm	2.3	n	N	3
28	16	Y	2	mm	3.1	y	Y	3
28	13	Y	2	mm	1.4	n	N	2
28	18	Y	2	mm	3.3	n	Y	4
28	21	Y	2	text	2.1	n	Y	4
28	22	Y	2	text	2.1	y	Y	3
28	23	Y	2	text	1.1	n	N	2
28	24	Y	2	text	2.1	y	N	8
28	26	Y	2	text	2.1	y	N	3
28	27	Y	2	text	1.1	n	N	4
28	30	Y	2	text	2.1	y	N	4
28	29	Y	2	text	2.1	n	N	9
28	31	Y	2	mm	1.1	n	Y	7
28	32	Y	2	mm	2.2	y	N	5

28	36	Y	2	mm	3.1	y	N	3
28	35	Y	2	mm	1.1	n	N	2
28	38	Y	2	mm	3.1	y	Y	4
28	37	Y	2	mm	1.1	n	N	4
28	40	Y	2	mm	3.1	y	Y	2
28	39	Y	2	mm	4.1	n	Y	3
29	1	Y	2	text	1.1	n	N	12
29	2	Y	2	text	1.1	y	Y	9
29	3	Y	2	text	2.1	n	N	9
29	4	Y	2	text	1.1	y	Y	3
29	8	Y	2	text	2.1	y	Y	7
29	7	Y	2	text	2.1	n	Y	1
29	9	Y	2	text	2.1	n	Y	8
29	6	Y	2	text	1.2	y	N	7
29	11	Y	2	mm	1.4	n	N	6
29	12	Y	2	mm	3.3	y	Y	4
29	17	Y	2	mm	3.2	y	Y	4
29	14	Y	2	mm	3.3	y	Y	5
29	15	Y	2	mm	2.3	n	N	3
29	16	Y	2	mm	3.1	y	N	3
29	13	Y	2	mm	1.4	n	N	3
29	18	Y	2	mm	3.3	n	N	4
29	21	Y	2	text	2.1	n	Y	6
29	22	Y	2	text	2.1	y	Y	8
29	23	Y	2	text	1.1	n	N	2
29	24	Y	2	text	2.1	y	N	6
29	26	Y	2	text	2.1	y	Y	9
29	27	Y	2	text	1.1	n	N	12
29	30	Y	2	text	2.1	y	N	4
29	29	Y	2	text	2.1	n	Y	25
29	31	Y	2	mm	1.1	n	N	7
29	32	Y	2	mm	2.2	y	N	4
29	36	Y	2	mm	3.1	y	Y	2
29	35	Y	2	mm	1.1	n	N	3
29	38	Y	2	mm	3.1	y	Y	5
29	37	Y	2	mm	1.1	n	N	2
29	40	Y	2	mm	3.1	y	Y	3
29	39	Y	2	mm	4.1	n	Y	1
30	1	Y	2	text	1.1	n	Y	8
30	2	Y	2	text	1.1	y	N	7
30	3	Y	2	text	2.1	n	N	9
30	4	Y	2	text	1.1	y	Y	12
30	8	Y	2	text	2.1	y	N	7
30	7	Y	2	text	2.1	n	Y	6
30	9	Y	2	text	2.1	n	N	9
30	6	Y	2	text	1.2	y	N	4
30	11	Y	2	mm	1.4	n	N	4
30	12	Y	2	mm	3.3	y	Y	2
30	17	Y	2	mm	3.2	y	Y	4
30	14	Y	2	mm	3.3	y	Y	3
30	15	Y	2	mm	2.3	n	Y	3
30	16	Y	2	mm	3.1	y	Y	5
30	13	Y	2	mm	1.4	n	N	3
30	18	Y	2	mm	3.3	n	Y	6
30	21	Y	2	text	2.1	n	Y	4
30	22	Y	2	text	2.1	y	Y	5

30	23	Y	2	text	1.1	n	N	8
30	24	Y	2	text	2.1	y	N	7
30	26	Y	2	text	2.1	y	N	9
30	27	Y	2	text	1.1	n	N	6
30	30	Y	2	text	2.1	y	Y	7
30	29	Y	2	text	2.1	n	Y	12
30	31	Y	2	mm	1.1	n	N	22
30	32	Y	2	mm	2.2	y	N	5
30	36	Y	2	mm	3.1	y	Y	2
30	35	Y	2	mm	1.1	n	N	2
30	38	Y	2	mm	3.1	y	Y	3
30	37	Y	2	mm	1.1	n	N	4
30	40	Y	2	mm	3.1	y	Y	6
30	39	Y	2	mm	4.1	n	Y	4
31	1	Y	2	text	1.1	n	N	18
31	2	Y	2	text	1.1	y	N	7
31	3	Y	2	text	2.1	n	N	6
31	4	Y	2	text	1.1	y	Y	8
31	8	Y	2	text	2.1	y	N	5
31	7	Y	2	text	2.1	n	N	7
31	9	Y	2	text	2.1	n	Y	2
31	6	Y	2	text	1.2	y	N	8
31	11	Y	2	mm	1.4	n	N	4
31	12	Y	2	mm	3.3	y	Y	2
31	17	Y	2	mm	3.2	y	Y	4
31	14	Y	2	mm	3.3	y	Y	8
31	15	Y	2	mm	2.3	n	N	3
31	16	Y	2	mm	3.1	y	Y	3
31	13	Y	2	mm	1.4	n	N	8
31	18	Y	2	mm	3.3	n	Y	4
31	21	Y	2	text	2.1	n	N	6
31	22	Y	2	text	2.1	y	N	4
31	23	Y	2	text	1.1	n	Y	6
31	24	Y	2	text	2.1	y	Y	4
31	26	Y	2	text	2.1	y	N	3
31	27	Y	2	text	1.1	n	N	4
31	30	Y	2	text	2.1	y	N	6
31	29	Y	2	text	2.1	n	N	2
31	31	Y	2	mm	1.1	n	N	7
31	32	Y	2	mm	2.2	y	N	7
31	36	Y	2	mm	3.1	y	Y	2
31	35	Y	2	mm	1.1	n	N	2
31	38	Y	2	mm	3.1	y	Y	2
31	37	Y	2	mm	1.1	n	N	4
31	40	Y	2	mm	3.1	y	N	5
31	39	Y	2	mm	4.1	n	Y	4
32	1	Y	2	text	1.1	n	Y	3
32	2	Y	2	text	1.1	y	N	4
32	3	Y	2	text	2.1	n	N	5
32	4	Y	2	text	1.1	y	N	3
32	8	Y	2	text	2.1	y	N	2
32	7	Y	2	text	2.1	n	Y	7
32	9	Y	2	text	2.1	n	N	2
32	6	Y	2	text	1.2	y	N	5
32	11	Y	2	mm	1.4	n	N	4
32	12	Y	2	mm	3.3	y	N	2

32	17	Y	2	mm	3.2	y	Y	6
32	14	Y	2	mm	3.3	y	Y	8
32	15	Y	2	mm	2.3	n	N	3
32	16	Y	2	mm	3.1	y	Y	7
32	13	Y	2	mm	1.4	n	N	2
32	18	Y	2	mm	3.3	n	Y	7
32	21	Y	2	text	2.1	n	Y	9
32	22	Y	2	text	2.1	y	N	3
32	23	Y	2	text	1.1	n	N	2
32	24	Y	2	text	2.1	y	N	7
32	26	Y	2	text	2.1	y	N	3
32	27	Y	2	text	1.1	n	N	4
32	30	Y	2	text	2.1	y	Y	4
32	29	Y	2	text	2.1	n	Y	6
32	31	Y	2	mm	1.1	n	N	7
32	32	Y	2	mm	2.2	y	N	5
32	36	Y	2	mm	3.1	y	N	7
32	35	Y	2	mm	1.1	n	N	2
32	38	Y	2	mm	3.1	y	N	4
32	37	Y	2	mm	1.1	n	N	4
32	40	Y	2	mm	3.1	y	Y	6
32	39	Y	2	mm	4.1	n	Y	7
33	1	Y	2	text	1.1	n	Y	5
33	2	Y	2	text	1.1	y	Y	4
33	3	Y	2	text	2.1	n	N	4
33	4	Y	2	text	1.1	y	Y	3
33	8	Y	2	text	2.1	y	Y	3
33	7	Y	2	text	2.1	n	Y	1
33	9	Y	2	text	2.1	n	N	2
33	6	Y	2	text	1.2	y	N	7
33	11	Y	2	mm	1.4	n	N	5
33	12	Y	2	mm	3.3	y	Y	4
33	17	Y	2	mm	3.2	y	Y	4
33	14	Y	2	mm	3.3	y	Y	8
33	15	Y	2	mm	2.3	n	N	5
33	16	Y	2	mm	3.1	y	N	7
33	13	Y	2	mm	1.4	n	N	3
33	18	Y	2	mm	3.3	n	Y	5
33	21	Y	2	text	2.1	n	N	3
33	22	Y	2	text	2.1	y	Y	3
33	23	Y	2	text	1.1	n	N	2
33	24	Y	2	text	2.1	y	N	7
33	26	Y	2	text	2.1	y	Y	4
33	27	Y	2	text	1.1	n	N	8
33	30	Y	2	text	2.1	y	N	4
33	29	Y	2	text	2.1	n	N	2
33	31	Y	2	mm	1.1	n	N	8
33	32	Y	2	mm	2.2	y	N	4
33	36	Y	2	mm	3.1	y	N	2
33	35	Y	2	mm	1.1	n	N	7
33	38	Y	2	mm	3.1	y	Y	5
33	37	Y	2	mm	1.1	n	N	4
33	40	Y	2	mm	3.1	y	Y	4
33	39	Y	2	mm	4.1	n	Y	4
34	1	Y	2	text	1.1	n	Y	3
34	2	Y	2	text	1.1	y	N	5

34	3	Y	2	text	2.1	n	N	3
34	4	Y	2	text	1.1	y	Y	5
34	8	Y	2	text	2.1	y	N	2
34	7	Y	2	text	2.1	n	Y	1
34	9	Y	2	text	2.1	n	Y	14
34	6	Y	2	text	1.2	y	N	2
34	11	Y	2	mm	1.4	n	N	5
34	12	Y	2	mm	3.3	y	Y	3
34	17	Y	2	mm	3.2	y	Y	4
34	14	Y	2	mm	3.3	y	N	8
34	15	Y	2	mm	2.3	n	N	3
34	16	Y	2	mm	3.1	y	N	3
34	13	Y	2	mm	1.4	n	N	7
34	18	Y	2	mm	3.3	n	N	4
34	21	Y	2	text	2.1	n	Y	3
34	22	Y	2	text	2.1	y	N	4
34	23	Y	2	text	1.1	n	N	2
34	24	Y	2	text	2.1	y	N	28
34	26	Y	2	text	2.1	y	Y	3
34	27	Y	2	text	1.1	n	N	4
34	30	Y	2	text	2.1	y	N	4
34	29	Y	2	text	2.1	n	Y	2
34	31	Y	2	mm	1.1	n	Y	7
34	32	Y	2	mm	2.2	y	N	5
34	36	Y	2	mm	3.1	y	N	2
34	35	Y	2	mm	1.1	n	N	3
34	38	Y	2	mm	3.1	y	N	2
34	37	Y	2	mm	1.1	n	N	4
34	40	Y	2	mm	3.1	y	N	7
34	39	Y	2	mm	4.1	n	Y	4
35	1	Y	2	text	1.1	n	Y	7
35	2	Y	2	text	1.1	y	N	6
35	3	Y	2	text	2.1	n	N	3
35	4	Y	2	text	1.1	y	N	3
35	8	Y	2	text	2.1	y	Y	4
35	7	Y	2	text	2.1	n	N	1
35	9	Y	2	text	2.1	n	Y	6
35	6	Y	2	text	1.2	y	N	4
35	11	Y	2	mm	1.4	n	N	8
35	12	Y	2	mm	3.3	y	Y	2
35	17	Y	2	mm	3.2	y	Y	8
35	14	Y	2	mm	3.3	y	Y	8
35	15	Y	2	mm	2.3	n	N	5
35	16	Y	2	mm	3.1	y	N	3
35	13	Y	2	mm	1.4	n	N	8
35	18	Y	2	mm	3.3	n	N	4
35	21	Y	2	text	2.1	n	Y	3
35	22	Y	2	text	2.1	y	Y	3
35	23	Y	2	text	1.1	n	N	5
35	24	Y	2	text	2.1	y	N	4
35	26	Y	2	text	2.1	y	N	6
35	27	Y	2	text	1.1	n	N	4
35	30	Y	2	text	2.1	y	N	6
35	29	Y	2	text	2.1	n	Y	9
35	31	Y	2	mm	1.1	n	N	7
35	32	Y	2	mm	2.2	y	N	5

35	36	Y	2	mm	3.1	y	N	5
35	35	Y	2	mm	1.1	n	N	2
35	38	Y	2	mm	3.1	y	Y	2
35	37	Y	2	mm	1.1	n	N	7
35	40	Y	2	mm	3.1	y	N	6
35	39	Y	2	mm	4.1	n	Y	4
36	1	N	2	text	1.1	n	Y	3
36	2	N	2	text	1.1	y	N	5
36	3	N	2	text	2.1	n	N	3
36	4	N	2	text	1.1	y	Y	6
36	8	N	2	text	2.1	y	Y	6
36	7	N	2	text	2.1	n	Y	6
36	9	N	2	text	2.1	n	N	5
36	6	N	2	text	1.2	y	N	2
36	11	N	2	mm	1.4	n	N	4
36	12	N	2	mm	3.3	y	Y	5
36	17	N	2	mm	3.2	y	Y	4
36	14	N	2	mm	3.3	y	Y	8
36	15	N	2	mm	2.3	n	N	3
36	16	N	2	mm	3.1	y	N	7
36	13	N	2	mm	1.4	n	N	2
36	18	N	2	mm	3.3	n	N	5
36	21	N	2	text	2.1	n	Y	3
36	22	N	2	text	2.1	y	Y	3
36	23	N	2	text	1.1	n	N	7
36	24	N	2	text	2.1	y	N	4
36	26	N	2	text	2.1	y	N	3
36	27	N	2	text	1.1	n	N	7
36	30	N	2	text	2.1	y	N	4
36	29	N	2	text	2.1	n	Y	2
36	31	N	2	mm	1.1	n	N	7
36	32	N	2	mm	2.2	y	N	8
36	36	N	2	mm	3.1	y	N	2
36	35	N	2	mm	1.1	n	N	5
36	38	N	2	mm	3.1	y	Y	2
36	37	N	2	mm	1.1	n	Y	8
36	40	N	2	mm	3.1	y	Y	6
36	39	N	2	mm	4.1	n	Y	5
37	1	N	2	text	1.1	n	N	3
37	2	N	2	text	1.1	y	N	5
37	3	N	2	text	2.1	n	N	3
37	4	N	2	text	1.1	y	N	5
37	8	N	2	text	2.1	y	N	2
37	7	N	2	text	2.1	n	Y	8
37	9	N	2	text	2.1	n	Y	8
37	6	N	2	text	1.2	y	N	2
37	11	N	2	mm	1.4	n	N	4
37	12	N	2	mm	3.3	y	Y	2
37	17	N	2	mm	3.2	y	Y	9
37	14	N	2	mm	3.3	y	N	8
37	15	N	2	mm	2.3	n	N	9
37	16	N	2	mm	3.1	y	N	8
37	13	N	2	mm	1.4	n	N	2
37	18	N	2	mm	3.3	n	Y	4
37	21	N	2	text	2.1	n	N	6
37	22	N	2	text	2.1	y	N	3

37	23	N	2	text	1.1	n	N	6
37	24	N	2	text	2.1	y	N	4
37	26	N	2	text	2.1	y	N	3
37	27	N	2	text	1.1	n	Y	8
37	30	N	2	text	2.1	y	N	4
37	29	N	2	text	2.1	n	Y	2
37	31	N	2	mm	1.1	n	N	8
37	32	N	2	mm	2.2	y	N	5
37	36	N	2	mm	3.1	y	N	6
37	35	N	2	mm	1.1	n	N	2
37	38	N	2	mm	3.1	y	Y	2
37	37	N	2	mm	1.1	n	N	6
37	40	N	2	mm	3.1	y	Y	6
37	39	N	2	mm	4.1	n	Y	4
38	1	N	2	text	1.1	n	Y	3
38	2	N	2	text	1.1	y	N	4
38	3	N	2	text	2.1	n	N	3
38	4	N	2	text	1.1	y	Y	3
38	8	N	2	text	2.1	y	Y	2
38	7	N	2	text	2.1	n	N	4
38	9	N	2	text	2.1	n	N	2
38	6	N	2	text	1.2	y	N	6
38	11	N	2	mm	1.4	n	Y	4
38	12	N	2	mm	3.3	y	Y	4
38	17	N	2	mm	3.2	y	Y	4
38	14	N	2	mm	3.3	y	N	6
38	15	N	2	mm	2.3	n	N	3
38	16	N	2	mm	3.1	y	N	4
38	13	N	2	mm	1.4	n	Y	2
38	18	N	2	mm	3.3	n	Y	7
38	21	N	2	text	2.1	n	N	3
38	22	N	2	text	2.1	y	Y	4
38	23	N	2	text	1.1	n	N	2
38	24	N	2	text	2.1	y	N	7
38	26	N	2	text	2.1	y	N	3
38	27	N	2	text	1.1	n	N	4
38	30	N	2	text	2.1	y	N	4
38	29	N	2	text	2.1	n	Y	8
38	31	N	2	mm	1.1	n	N	7
38	32	N	2	mm	2.2	y	N	5
38	36	N	2	mm	3.1	y	N	6
38	35	N	2	mm	1.1	n	N	2
38	38	N	2	mm	3.1	y	Y	2
38	37	N	2	mm	1.1	n	N	5
38	40	N	2	mm	3.1	y	Y	6
38	39	N	2	mm	4.1	n	Y	4
39	1	N	2	text	1.1	n	N	3
39	2	N	2	text	1.1	y	N	5
39	3	N	2	text	2.1	n	N	3
39	4	N	2	text	1.1	y	N	4
39	8	N	2	text	2.1	y	Y	2
39	7	N	2	text	2.1	n	N	6
39	9	N	2	text	2.1	n	N	2
39	6	N	2	text	1.2	y	N	4
39	11	N	2	mm	1.4	n	N	5
39	12	N	2	mm	3.3	y	Y	5

39	17	N	2	mm	3.2	y	Y	4
39	14	N	2	mm	3.3	y	Y	8
39	15	N	2	mm	2.3	n	N	7
39	16	N	2	mm	3.1	y	N	3
39	13	N	2	mm	1.4	n	Y	2
39	18	N	2	mm	3.3	n	Y	4
39	21	N	2	text	2.1	n	N	3
39	22	N	2	text	2.1	y	Y	3
39	23	N	2	text	1.1	n	N	7
39	24	N	2	text	2.1	y	N	4
39	26	N	2	text	2.1	y	Y	5
39	27	N	2	text	1.1	n	N	4
39	30	N	2	text	2.1	y	N	6
39	29	N	2	text	2.1	n	Y	6
39	31	N	2	mm	1.1	n	N	6
39	32	N	2	mm	2.2	y	N	7
39	36	N	2	mm	3.1	y	N	4
39	35	N	2	mm	1.1	n	N	2
39	38	N	2	mm	3.1	y	Y	4
39	37	N	2	mm	1.1	n	N	5
39	40	N	2	mm	3.1	y	Y	6
39	39	N	2	mm	4.1	n	Y	3
40	1	N	2	text	1.1	n	Y	5
40	2	N	2	text	1.1	y	N	4
40	3	N	2	text	2.1	n	N	2
40	4	N	2	text	1.1	y	N	3
40	8	N	2	text	2.1	y	Y	2
40	7	N	2	text	2.1	n	Y	1
40	9	N	2	text	2.1	n	Y	14
40	6	N	2	text	1.2	y	N	2
40	11	N	2	mm	1.4	n	N	4
40	12	N	2	mm	3.3	y	Y	23
40	17	N	2	mm	3.2	y	Y	4
40	14	N	2	mm	3.3	y	Y	8
40	15	N	2	mm	2.3	n	N	3
40	16	N	2	mm	3.1	y	Y	3
40	13	N	2	mm	1.4	n	N	2
40	18	N	2	mm	3.3	n	Y	3
40	21	N	2	text	2.1	n	Y	2
40	22	N	2	text	2.1	y	Y	3
40	23	N	2	text	1.1	n	N	2
40	24	N	2	text	2.1	y	N	4
40	26	N	2	text	2.1	y	N	2
40	27	N	2	text	1.1	n	N	4
40	30	N	2	text	2.1	y	N	2
40	29	N	2	text	2.1	n	Y	2
40	31	N	2	mm	1.1	n	N	7
40	32	N	2	mm	2.2	y	N	5
40	36	N	2	mm	3.1	y	Y	2
40	35	N	2	mm	1.1	n	N	2
40	38	N	2	mm	3.1	y	Y	2
40	37	N	2	mm	1.1	n	N	4
40	40	N	2	mm	3.1	y	Y	6
40	39	N	2	mm	4.1	n	Y	34
41	1	N	2	text	1.1	n	N	3
41	2	N	2	text	1.1	y	Y	4

41	3	N	2	text	2.1	n	N	4
41	4	N	2	text	1.1	y	N	3
41	8	N	2	text	2.1	y	N	2
41	7	N	2	text	2.1	n	Y	1
41	9	N	2	text	2.1	n	Y	5
41	6	N	2	text	1.2	y	N	2
41	11	N	2	mm	1.4	n	N	23
41	12	N	2	mm	3.3	y	Y	2
41	17	N	2	mm	3.2	y	Y	4
41	14	N	2	mm	3.3	y	Y	3
41	15	N	2	mm	2.3	n	N	3
41	16	N	2	mm	3.1	y	Y	5
41	13	N	2	mm	1.4	n	N	2
41	18	N	2	mm	3.3	n	Y	3
41	21	N	2	text	2.1	n	Y	5
41	22	N	2	text	2.1	y	Y	3
41	23	N	2	text	1.1	n	N	2
41	24	N	2	text	2.1	y	N	3
41	26	N	2	text	2.1	y	N	3
41	27	N	2	text	1.1	n	N	3
41	30	N	2	text	2.1	y	N	6
41	29	N	2	text	2.1	n	Y	3
41	31	N	2	mm	1.1	n	N	3
41	32	N	2	mm	2.2	y	N	6
41	36	N	2	mm	3.1	y	Y	2
41	35	N	2	mm	1.1	n	N	5
41	38	N	2	mm	3.1	y	Y	3
41	37	N	2	mm	1.1	n	N	6
41	40	N	2	mm	3.1	y	Y	3
41	39	N	2	mm	4.1	n	Y	4
42	1	N	2	text	1.1	n	N	4
42	2	N	2	text	1.1	y	N	4
42	3	N	2	text	2.1	n	N	5
42	4	N	2	text	1.1	y	N	5
42	8	N	2	text	2.1	y	Y	2
42	7	N	2	text	2.1	n	Y	1
42	9	N	2	text	2.1	n	N	2
42	6	N	2	text	1.2	y	N	2
42	11	N	2	mm	1.4	n	N	6
42	12	N	2	mm	3.3	y	Y	4
42	17	N	2	mm	3.2	y	Y	4
42	14	N	2	mm	3.3	y	Y	4
42	15	N	2	mm	2.3	n	N	3
42	16	N	2	mm	3.1	y	N	1
42	13	N	2	mm	1.4	n	N	3
42	18	N	2	mm	3.3	n	Y	4
42	21	N	2	text	2.1	n	Y	4
42	22	N	2	text	2.1	y	Y	3
42	23	N	2	text	1.1	n	N	2
42	24	N	2	text	2.1	y	N	4
42	26	N	2	text	2.1	y	N	3
42	27	N	2	text	1.1	n	N	4
42	30	N	2	text	2.1	y	N	5
42	29	N	2	text	2.1	n	Y	5
42	31	N	2	mm	1.1	n	N	3
42	32	N	2	mm	2.2	y	N	5

42	36	N	2	mm	3.1	y	N	2
42	35	N	2	mm	1.1	n	N	2
42	38	N	2	mm	3.1	y	Y	4
42	37	N	2	mm	1.1	n	N	4
42	40	N	2	mm	3.1	y	Y	6
42	39	N	2	mm	4.1	n	Y	4
43	1	N	2	text	1.1	n	N	4
43	2	N	2	text	1.1	y	N	4
43	3	N	2	text	2.1	n	N	8
43	4	N	2	text	1.1	y	Y	3
43	8	N	2	text	2.1	y	N	7
43	7	N	2	text	2.1	n	N	1
43	9	N	2	text	2.1	n	Y	2
43	6	N	2	text	1.2	y	N	5
43	11	N	2	mm	1.4	n	N	4
43	12	N	2	mm	3.3	y	Y	2
43	17	N	2	mm	3.2	y	Y	4
43	14	N	2	mm	3.3	y	Y	6
43	15	N	2	mm	2.3	n	Y	3
43	16	N	2	mm	3.1	y	N	3
43	13	N	2	mm	1.4	n	N	2
43	18	N	2	mm	3.3	n	Y	3
43	21	N	2	text	2.1	n	Y	3
43	22	N	2	text	2.1	y	Y	3
43	23	N	2	text	1.1	n	N	4
43	24	N	2	text	2.1	y	N	4
43	26	N	2	text	2.1	y	N	3
43	27	N	2	text	1.1	n	Y	7
43	30	N	2	text	2.1	y	N	4
43	29	N	2	text	2.1	n	Y	2
43	31	N	2	mm	1.1	n	N	4
43	32	N	2	mm	2.2	y	N	4
43	36	N	2	mm	3.1	y	N	7
43	35	N	2	mm	1.1	n	N	4
43	38	N	2	mm	3.1	y	N	2
43	37	N	2	mm	1.1	n	N	4
43	40	N	2	mm	3.1	y	Y	8
43	39	N	2	mm	4.1	n	Y	4
44	1	N	2	text	1.1	n	N	8
44	2	N	2	text	1.1	y	Y	4
44	3	N	2	text	2.1	n	Y	5
44	4	N	2	text	1.1	y	Y	3
44	8	N	2	text	2.1	y	Y	2
44	7	N	2	text	2.1	n	Y	1
44	9	N	2	text	2.1	n	Y	3
44	6	N	2	text	1.2	y	N	2
44	11	N	2	mm	1.4	n	N	4
44	12	N	2	mm	3.3	y	Y	7
44	17	N	2	mm	3.2	y	Y	4
44	14	N	2	mm	3.3	y	Y	8
44	15	N	2	mm	2.3	n	N	3
44	16	N	2	mm	3.1	y	N	3
44	13	N	2	mm	1.4	n	N	2
44	18	N	2	mm	3.3	n	Y	3
44	21	N	2	text	2.1	n	Y	3
44	22	N	2	text	2.1	y	N	3

44	23	N	2	text	1.1	n	Y	3
44	24	N	2	text	2.1	y	Y	4
44	26	N	2	text	2.1	y	N	3
44	27	N	2	text	1.1	n	N	8
44	30	N	2	text	2.1	y	N	4
44	29	N	2	text	2.1	n	Y	3
44	31	N	2	mm	1.1	n	N	6
44	32	N	2	mm	2.2	y	N	5
44	36	N	2	mm	3.1	y	Y	5
44	35	N	2	mm	1.1	n	N	2
44	38	N	2	mm	3.1	y	Y	2
44	37	N	2	mm	1.1	n	N	4
44	40	N	2	mm	3.1	y	Y	6
44	39	N	2	mm	4.1	n	Y	2
45	1	N	2	text	1.1	n	N	6
45	2	N	2	text	1.1	y	Y	7
45	3	N	2	text	2.1	n	Y	5
45	4	N	2	text	1.1	y	N	3
45	8	N	2	text	2.1	y	Y	2
45	7	N	2	text	2.1	n	N	5
45	9	N	2	text	2.1	n	N	2
45	6	N	2	text	1.2	y	Y	7
45	11	N	2	mm	1.4	n	Y	8
45	12	N	2	mm	3.3	y	Y	5
45	17	N	2	mm	3.2	y	Y	3
45	14	N	2	mm	3.3	y	Y	3
45	15	N	2	mm	2.3	n	Y	3
45	16	N	2	mm	3.1	y	N	3
45	13	N	2	mm	1.4	n	Y	9
45	18	N	2	mm	3.3	n	Y	3
45	21	N	2	text	2.1	n	Y	3
45	22	N	2	text	2.1	y	N	8
45	23	N	2	text	1.1	n	N	2
45	24	N	2	text	2.1	y	N	8
45	26	N	2	text	2.1	y	N	5
45	27	N	2	text	1.1	n	N	4
45	30	N	2	text	2.1	y	N	5
45	29	N	2	text	2.1	n	Y	2
45	31	N	2	mm	1.1	n	N	7
45	32	N	2	mm	2.2	y	N	3
45	36	N	2	mm	3.1	y	N	2
45	35	N	2	mm	1.1	n	N	5
45	38	N	2	mm	3.1	y	N	2
45	37	N	2	mm	1.1	n	N	9
45	40	N	2	mm	3.1	y	Y	7
45	39	N	2	mm	4.1	n	Y	1
46	1	N	2	text	1.1	n	N	5
46	2	N	2	text	1.1	y	N	8
46	3	N	2	text	2.1	n	Y	7
46	4	N	2	text	1.1	y	Y	6
46	8	N	2	text	2.1	y	Y	3
46	7	N	2	text	2.1	n	Y	5
46	9	N	2	text	2.1	n	Y	5
46	6	N	2	text	1.2	y	N	17
46	11	N	2	mm	1.4	n	Y	6
46	12	N	2	mm	3.3	y	Y	2

46	17	N	2	mm	3.2	y	Y	4
46	14	N	2	mm	3.3	y	Y	3
46	15	N	2	mm	2.3	n	Y	3
46	16	N	2	mm	3.1	y	Y	1
46	13	N	2	mm	1.4	n	N	2
46	18	N	2	mm	3.3	n	Y	4
46	21	N	2	text	2.1	n	Y	8
46	22	N	2	text	2.1	y	Y	3
46	23	N	2	text	1.1	n	N	5
46	24	N	2	text	2.1	y	Y	5
46	26	N	2	text	2.1	y	N	3
46	27	N	2	text	1.1	n	N	7
46	30	N	2	text	2.1	y	N	3
46	29	N	2	text	2.1	n	Y	2
46	31	N	2	mm	1.1	n	N	7
46	32	N	2	mm	2.2	y	Y	7
46	36	N	2	mm	3.1	y	Y	2
46	35	N	2	mm	1.1	n	N	5
46	38	N	2	mm	3.1	y	Y	5
46	37	N	2	mm	1.1	n	N	8
46	40	N	2	mm	3.1	y	Y	3
46	39	N	2	mm	4.1	n	Y	2

APPENDIX D

Focus Group Consent Form

1. You are being asked for your consent to participate in a focus group study. This study is being conducted by Alison E. Philpotts under the direction of Dr. Judy M. Olson of the Geography Department at Michigan State University.

2. The objective of this study is to assess the potential benefits of multimedia as an educational device for learning geography, especially by dyslexic students.

3. You have been selected to help evaluate the materials created for this study. You will view four sections of a geography lesson created in two formats, traditional text and interactive multimedia, with assistance as needed. A group discussion will then take place.

4. The length of time for participation is approximately 2-2.5 hours. There will be approximately one hour allotted to viewing the educational materials, followed by a break and approximately one hour of discussion.

5. There are no foreseeable risks to you if you participate in this study.

6. Participation in this study is voluntary. You may discontinue participation at any time without penalty.

7. For participating, you will receive $25 and a copy of the lesson materials.

8. You are assured that participants will remain anonymous in any reports of this research. Specific statements may be used in the final report but they will not be tied to any individual. Within these restrictions you may receive a copy of results upon request.

9. An assistant will be taking notes during the session. The session will also be recorded on video tape. ONLY the researchers and note taker will have access to the video tapes, and the tapes will be erased at the conclusion of the study.

10. You may receive further information about the study following this session if you wish. On the following page is the name, address, and phone information for you to keep in case you wish to contact the researchers later.

I understand the above statements and freely consent to participate in this study.

________________________________ ________________

Signature Date

Contact information for the focus group discussion on evaluation of multimedia as an educational device for geography, especially for dyslexic students.

Alison E. Philpotts
Department of Geography
Natural Science Building
Michigan State University
East Lansing, MI 48824

voice: (517) 332-5377
fax: (517) 432-1671
email: philpot1@pilot.msu.edu

Professor Judy M. Olson
Department of Geography
Natural Science Building
Michigan State University
East Lansing MI 48824

voice: (517) 353-8757
fax: (517) 432-1671
email: olsonj@pilot.msu.edu

Thank you for your participation.

Requesting participation by teachers/tutors in a focus group discussion to evaluate multimedia materials.

Dear ____________:

I am requesting your participation in a focus group discussion on (date, time, and place). I have created a geography lesson in two formats: traditional text and interactive multimedia. The lesson focuses on Michigan coastal dunes and encompasses themes listed in the eighth grade geography standards. I will be testing this lesson on both dyslexic and non-dyslexic eighth grade students. I would appreciate your expertise and opinions on improving my lesson and pointing out areas, tasks, or concepts that may need attention before students work with the materials.

Knowledge of Michigan dunes is **NOT** needed to participate, nor do you need to be familiar with geography, computers or interactive multimedia. Your experience and expertise in education and tutoring is the reason I am asking for your participation.

I expect the entire event to take roughly 2-2.5 hours. Approximately one hour will be allotted to viewing the educational material. The remainder of the time will be devoted to discussion.

You will be paid $25 as a token of appreciation for your participation. Refreshments will be provided. Also, everyone participating may keep a set of the educational materials.

I would greatly appreciate your participation in this study. The benefits of this study may be insights into the usefulness of interactive multimedia as an educational device for learning geography, especially for those with dyslexia.

Sincerely,

Alison E. Philpotts,
Ph.D. Candidate

If you have any questions please contact one of the following researchers:

Alison E. Philpotts, voice: (517) 332-5377 email: philpot1@pilot.msu.edu
Professor Judy M. Olson voice: (517) 353-8757 email: olsonj@pilot.msu.edu
Mailing Address: Department of Geography, Natural Science Building
Michigan State University, East Lansing MI 4882

Dear Parent or guardian:

I am conducting a study on the potential benefits of interactive multimedia in education and am asking permission for your child to participate.

I will ask students to study a four-part geography lesson. The lesson will use both traditional materials such as text and maps and graphs on paper and also computer presented materials. At the end of each part and at the end of all four parts students will be asked questions.

Your child's name will remain confidential. Reports will NOT link any names with any specific results. Performance on the lesson will also have no direct bearing on your child's grades.

Several benefits may occur from participating in this study. Students will learn something about a geographical environment in Michigan. Additional benefits to the student may include an improved understanding of reading graphic materials such as maps and diagrams and an increased comfort in using computers and multimedia. The entire study in general should give some insights into the usefulness of multimedia as an educational device.

I hope you will sign the attached consent form allowing your child to participate. Your child will also be asked verbally if he/she is willing to participate at the time of the study.

If you have any questions please feel free to contact:

Professor Judy M. Olson	voice: (517) 353-8757
Department of Geography	fax: (517) 432-1671
Natural Science Building	email: olsonj@pilot.msu.edu
Michigan State University	East Lansing MI 48824

Or

Alison E. Philpotts	voice: (517) 332-5377
Department of Geography	fax: (517) 432-1671
Natural Science Building	email: philpot1@pilot.msu.edu
Michigan State University	East Lansing MI 48824

Thank you,

Alison E. Philpotts

Parental Consent Form

1. You are being asked consent for your child's participation in an educational study. This study is being conducted by Alison E. Philpotts under the direction of Dr. Judy M. Olson of the Geography Department at Michigan State University.

2. The objective of this study is to assess the potential benefits of multimedia for learning geography lessons.

3. Students will first take a pre-test and then proceed through a four-part geography lesson. Students will be asked questions at the end of each part and at the end of all parts.

4. The total length of time for participation is approximately 1.5-2 hours, although times may vary for individual students. Each section takes approximately 15-20 minutes with an additional 5 minutes for questions. Follow-up questions at the completion of the four sections are estimated to take 10-15 minutes.

5. There are no foreseeable risks to your child if he/she participates in this study.

6. Participation in this study is purely voluntary, and your child may discontinue participation at any time without penalty.

7. Participants will remain anonymous in any reports of this research, and scores will NOT be calculated into your child's school grades.

8. You may receive further information about the study at any time following this session. The names, addresses, and phone numbers of the researchers are given in the cover letter.

Please sign one of two options.

I understand the above statements and freely **consent** to my child's participation in this study.

Child's Name	Parent or Guardian Signature	Date

I do **not** want my child to participate

Child's Name	Parent or Guardian Signature	Date