SOUTH DAKOTA SECONDARY SCHOOL STUDENTS' SCIENCE ATTITUDES AND THE IMPLEMENTATION OF NASA'S DIGITAL LEARNING NETWORK'S "CAN A SHOEBOX FLY? CHALLENGE"

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CHAPTER I

INTRODUCTION

Background

The National Aeronautics and Space Administration (NASA) has taken steps to "inspire the next generation of explorers" through its education programs. To achieve this objective, NASA tries to engage, inspire, motivate, and challenge students and teachers to enhance their knowledge of science, technology, engineering, and mathematics (STEM). One of the numerous education programs of NASA is the Digital Learning Network (DLN). This program uses two-way audio and video videoconferencing to share the knowledge and expertise of scientists, engineers, and researchers with students and teachers. The DLN began in 2004 with three hub sites. Today, there is a hub at each of the ten NASA centers. The DLN has approximately forty-four "canned" events. It also offers opportunities for classroom teachers to request guest speakers for a specific topic.

NASA's history of education programs date back to 1958 when NASA was formed. This legislation authorized NASA to share the knowledge of Earth and space with the public to ensure that the United States remains a leader in science, engineering, and technology. With state of the art laboratories and facilities, and awe-inspiring astronauts, engineers, and scientists, NASA's resources have continued to provide students and teachers with opportunities to engage, inspire, and motivate in the nature of science and discovery for over five decades. In 1992, NASA published its first agency-wide educational strategy by stating “it is NASA’s policy to use its inspiring missions, its unique facilities, and its specialized workforce to conduct and facilitate science, mathematics, engineering, and technology education programs and activities” (NASA, 1992, p.5). In other words, the broad goals of NASA’s mission in K-12 education include capturing the students’ interests in STEM and to channel that interest into STEM career paths. The 2004 President’s Commission Report states:

> space exploration captures the imagination of America’s children and adults. The challenge before us is to leverage the journey to the space frontier to engage learners of all ages and interests. In addition, we must focus on training of the workforce needed for the success of the long-term exploration program. The education community, working with NASA, must aggressively educate and train a new generation of explorers – there is perhaps no greater imperative for ensuring successful and sustainable space exploration by this nation (Executive Office of the United States, 2004, p. 41).

The report goes on to say, “the future is for our children and they must be trained to sustain this nation’s quality of life in a more competitive world through technological achievement and economic growth. We must reverse the decline of students entering into technical fields and the shortage of well-trained science teachers. We must take advantage of the unique opportunity afforded by this vision to inspire our youth and teachers to focus on mathematics, science, and engineering education” (Executive Office of the United States, 2004, p. 47). In 2007, NASA states that its mission is “To pioneer the future in space exploration, scientific discovery, and aeronautics research” (National

Aeronautics and Space Administration, 2007, p.2). Loston, Steffen and McGee (2005) assert "NASA is directly affected by the decline in the number of students pursuing mathematics and science careers. The size of the Agency's technical workforce ages 20-30 is only one-third that of its workforce ages 60-70, and NASA is encountering shortages in critical skills as older professionals retire" (p. 148).

Paralleling , science education in general was transforming. In the 1960s, science curriculum was undergoing a reform from the traditional classroom where the teacher was the transmitter of knowledge to a classroom that promoted hands-on learning for more effective science learning. This allowed students to discover learning and construct their own meanings, thus a push for constructivism in schools. In the science and mathematics classrooms, this theory has manifested itself as inquiry-based learning. As the number of STEM field graduates has decreased over the decades, the push for inquiry learning in the science classroom has grown. Several recent reports on education in the United States have some disturbing statistics. In 1983, "A Nation at Risk" report challenged the public education systems and public priorities and jump-started years of education reform. This report warned that the education system was not meeting the needs of a more diversified nation. President George Bush, in 2002, threatened schools to improve students' basic skills or face sanctions with the No Child Left Behind Act. In the 2005 National Assessment of Education Progress, results show that 29% of 8^{th} graders tested at or above proficiency and 18% of high school seniors performed at or above proficient levels in science (Grigg, Lauko, & Brockway, 2006, p.1). In a 2009 report, U.S. students ranked 14th in science and 25th in mathematics when compared to students in other countries. These students ranked behind Solvenia, Estonia, Canada, Japan, and

Western Europe (Fleischman, Hopstock, Pelczar, & Shelley, 2010, p.24 & 18). Human capital has always been the key to the United State's economic power. In fact, the National Science Teacher's Association has embedded inquiry into the National Science Education Standards and has encouraged exploring inquiry through the 5 E Instructional Model. More doom-and-gloom reports have been released in the last 30 years, but the most compelling report to warn us about the United States falling behind in education is "Rising Above the Gathering Storm." This report states "our lack of preparation will reduce the ability of the United States to compete in such a world" (National Academy of Sciences, 2007, p. 25). The report goes on to say "at the beginning of the 21st century, the United States stands at a crossroads. The only way for this nation to remain a high-wage, high-technology country is to remain at the forefront of innovation. Achieving this goal will require that the nation remain a leader in the scientific and technological research that contributes so heavily to innovation" (National Academy of Sciences, 2007, p. 400).

Statement of Problem

To what extent will student attitudes in science change after participating in NASA's Digital Learning Network's "Can a Shoebox Fly? Challenge." The DLN has curriculum modules that are specifically designed for classroom use. The DLN team identifies an area of need in STEM and then develops a module to meet that particular need. A rubric is used to help develop and rate the module for developmental appropriateness, focus questions, objectives, meeting national standards, videoconference interactivity and content. The module must rate a 3 or 4 in each category to be reviewed and broadcasted. Almost all of the modules are in the 5 E format, and currently some of the modules contain pre and post tests for the students participating in the DLN event yet the data is not used to assess effectiveness of the presentation, scientific literacy, or student attitudes toward science.

Purpose of the Study

The purpose of this study is to assess the degree to which the Digital Learning Network (DLN) will promote scientific attitudes in the secondary science classroom in South Dakota. This research will be used to ascertain if the secondary students participating in a DLN event will promote a more positive attitude toward science.

This information will be used to determine if the Shoebox Challenge will create a change in attitude in students in science, as well as, inspire the next generation of explorers to pursue STEM careers. It will also be used to determine if a need exists to modify the DLN modules to be more effective to promote scientific attitudes.

Research Questions

The research questions of this study are as follows:

1. To what extent will the DLN module “Can a Shoebox Fly? Challenge” promotes scientific attitudes in the secondary science curriculum?
2. Is there a gender difference in science attitudes with regards to “Can a Shoebox Fly? Challenge?”
3. How effective the DLN is with regards to student interest in STEM careers?
4. Does a need exist to modify the DLN module “Can A Shoebox Fly? Challenge?”

For research question one, the null hypothesis is that there will be no differences in students' scientific attitudes. For research question two, the null hypothesis is that student population who participated in the DLN events will have no difference in gender.

Significance of the Study

This study is designed to benefit the students in a South Dakota secondary school science class as well as NASA's DLN. The National Research Council determined in their 2008 Review and Critique of NASA's Elementary and Secondary Education Programs that "the Elementary and Secondary programs is not realizing NASA's potential as a resource for education as effectively as could be hoped" (National Research Council, 2008; p. 9). It goes on to criticize the DLN staff by saying that it has "weak standards for assessing the educational merits of the modules….Future reviews should focus on the educational merits and also examine the scientific content of the modules…" (National Research Council, 2008, p. 72).

Assumptions

The school involved is a small, rural school thus the population size is small. The basic assumptions in this research are 1. The students who participate will express their answers honestly, and 2. The DLN presenter is knowledgeable of the information presented during the DLN event.

Definition of Terms

The following terms and definitions were used throughout the study. Definitions and explanations are below:

<u>5E Instructional Model – Engage, Exploration, Explanation, Elaboration, and Evaluation</u>

<u>Engage:</u> "The teacher or a curriculum task accesses the learners' prior knowledge and helps them become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The activity should make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the learning outcomes of current activities" (Baybee, et al, 2008, p. 1).

<u>Exploration</u>: "Exploration experiences provide students with a common base of activities within which current concepts (i.e., misconceptions), processes, and skills are identified and conceptual change is facilitated. Learners may complete lab activities that help them use prior knowledge to generate new ideas, explore questions and possibilities, and design and conduct a preliminary investigation" (Baybee, et al, 2008, p. 2).

<u>Explanation</u>: "The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills or behaviors. This phase also provides opportunities for teachers to directly introduce a concept, process, or skill. Learners explain their understanding of the concept. An explanation

from the teacher or the curriculum may guide them toward a deeper understanding, which is a critical part of this phase" (Baybee, et al, 2008, p.2).

Elaboration: "Teachers challenge and extend students' conceptual understanding and skills. Through new experiences, the students develop deeper and broader understanding, more information, and adequate skills. Students apply their understanding of the concept by conducting additional activities" (Baybee, et. al, 2008, p.2).

Evaluation: "The evaluation phase encourages students to assess their understanding and abilities and provides opportunities for teachers to evaluate student progress toward achieving the educational objectives." (Baybee, et. al, 2008, p.2)

Attitudes – A learned tendency to respond in a consistently favorable or unfavorable manner with respect to a given attitude object (Fishbein & Ajzen, 1975).

Constructivism – A learning theory in which learners construct and are actively involved in making their own meanings based on prior knowledge.

Digital Learning Network (DLN) – The DLN provides videoconferencing to schools at no-charge. It is a two-way audio and video where students and teachers participate in live lectures and demonstrations with NASA personnel including scientists, engineers, and researchers (Starr, 2007).

DLN Event – A specific DLN module presented at a specific time. Teachers select from a menu of topics and schedule a time for participating in the videoconference.

DLN Module – A self-contained presentation used to address a specific topic within NASA's Mission Directorates (Aeronautics Research, Space Operations, Science, and Exploration Systems).

Inquiry – "A multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations…" (National Research Council, 1996, p.23).

Scientific Inquiry – "Refers to the diverse ways in which scientists study the natural world around and propose explanations based on evidence derived from their work…also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (National Research Council, 1996, p.23).

Scientific Literacy – "The knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity" (National Research Council, 1996, p.22).

Science Related Attitudes – "A general and enduring positive or negative feeling about science" (Koballa & Crawley, 1985, p. 222).

Science, Technology, Engineering, and Mathematics (STEM) – This is a term used in education when discussing the areas of science, technology, engineering, and math. The concern is that the United States is not educating a sufficient number of teachers and professionals in the above careers. The trends in the United States are not comforting when one considers that schools have a deficit in scientists, engineers, and mathematicians necessary to maintain our global economic leadership.

Student Attitudes – In this research, attitudes, as in attitudes towards science, are "feelings, beliefs, and values held about an object that may be the enterprise of science, school science, the impact of science on society or scientists themselves" (Osbourne et al, 2003, p. 1053).

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Chapter II provides a review of the literature pertinent to this study. To promote scientific literacy, NASA's educational materials, including the Digital Learning Network (DLN), are aligned to the National Science, Mathematics, and Technology standards. The DLN modules are designed in the 5E Instructional Model to promote inquiry learning. This review of the literature consists of Practical and Theoretical Reasoning in Science Education, Educational Philosophies that underlie scientific literacy, Student Attitudes toward science, NASA's education programs, and distance learning/videoconferencing.

Practical and Theoretical Reasoning in the Theory

One of the forerunners of learning is constructivism. Students are active learners and are allowed to construct their own knowledge. It's hard to imagine that constructivism is rooted in Socratic questioning where students of Socrates realized what they did and did not know. What a learner currently knows is important for future learning as the learner builds on what he knows and has experienced to construct or build new understandings to problems and situations. According to Barnes and Barnes (2005), “learners need to feel engaged in the learning process by reconciling new ideas and experiences with current conceptual frameworks” (p. 63).

The science classroom provides the opportunity for students to learn science by “doing” science. Constructivism theory provides for the teacher to apply this approach to learning through inquiry. In a traditional middle and high school classroom, the teacher is the deliverer of knowledge through a lecture format. In a contemporary classroom that uses an inquiry-based approach, the teacher acts as a facilitator and understands “the notion that learners respond to their sensory experiences by building or constructing in their minds schemas or cognitive structures which constitute the meaning and understanding of their world” (Saunders, 1992; p. 136). In other words, students make connections between prior knowledge and new experiences.

After World War II, there were pressures to change public school education. Chiappetta states “War World II brought about political and social pressure that shaped the goals of public school education. School science programs stressed the practical aspect of science so that students could take their place as productive members of society” (p. 21). When Sputnik launched in 1957 by the Russians, it launched a massive education reform in science and mathematics. This pivotal moment in history brought to the forefront that science, engineering, and technology in the United States was lagging behind the Russians. Because of this, science and mathematics education under went a major reform. There were many contributors to this reform movement during this time such as Schwab, Ausubel, Gardner and Piaget (Chiappetta, 2008, p. 22). The three-phase learning cycle was developed at the University of California, Berkeley (Bosse et al;

2010). There were several reports released during the 1990s that brought to light the decline in the United States' ability to compete in the world market and the constructivist theory reemerged as a well-used approach to teaching science, and an approach that is based on cognitive research. Inquiry became the leading theory of science education reform and out of this the three-phase learning cycle morphed the 5E Instruction Model, which has become a highly effective model to use in science education. The 5E Model was developed by the Biological Science Curriculum Study (BSCS) and plays a significant role in curriculum development – including 's curriculum. There are five phases in the 5E model and consists of the following phases: engagement, exploration, explanation, elaboration, and evaluation. According to Bybee, "each phase has a specific function and contributes to the teacher's coherent instruction and the students' formulating a better understanding of scientific and technological knowledge, attitudes, and skills" (p. 4). These should be considered processes through which students learn science.

Educational Philosophies that Underlie Scientific Literacy

Promoting scientific literacy has become the main goal of science education in the United States and all over the world. It also undergirds the National Science Standards. These standards were produced by the National Research Council (NRC) in 1995 to provide standards that members in the science teaching community strive to achieve. These standards address six aspects of science education to achieve scientific literacy for America. The six aspects are:

1. Science teaching
2. Professional Development for teachers of science
3. Assessment in science which provides a criteria to determine achievement of the standards
4. Science content – what students should know, understands, and be able to do specific in science at specific grade levels.
5. Science education programs at the school and district levels
6. Science education systems at the district or local levels, state, and national levels including colleges, universities, museums, etc. (US National Center for Education Statistics, 1996).

NASA's Education Programs

Since 1958, NASA has had a responsibility to inspire, engage, and challenge students. According to the NRC report on NASA's education program, "a federal agency like NASA has a unique and important role to play in motivating and inspiring students to consider STEM careers and citizens to become more knowledgeable" (National Research Council, 2008, p. viii). The oldest continuous education program in NASA is the Aerospace Education Services Project (formally Program) (AESP). AESP is designed to provide customized workshops to educators utilizing NASA related curriculum that provides real-world applications of the curriculum, and also to educate students in STEM fields and careers. Marks (1975), Grigsby (1979), Robertson (1998), Eskridge (1999) have all studied the influence of AESP in the classroom and on teacher development. Eskridge (1999) in his dissertation described how NASA's educational materials were implemented in the classroom to promote scientific literacy. Marks (1975) studied in his dissertation the "characteristics of aerospace education workshop participants in relation to curriculum and instructions utilization after the completion of a workshop which NASA participated" (p.4). Marks found that 51% of the workshop participants were utilizing aerospace concepts in their teaching and that greater than 90% of participants "felt the aerospace education workshop was beneficial to their teaching methods" (p. 69 & 70).

Robertson (1998) in his dissertation studied how educators of Tennessee Space Week used and implemented NASA and other aerospace internet websites.

Grigsby (1979) studied in her dissertation the need for aerospace education in Oklahoma. Her results indicated that approximately 79% of workshop participants utilized NASA education materials in their classrooms.

Loston et al (2005) state "inquiry shapes the way NASA organizes its missions and the way that scientists conduct their investigation….NASA has adopted inquiry as a primary approach because research suggests that inquiry is an effective method for improving students' attitudes toward science and increasing scientific literacy" (p. 147).

The DLN was established in 2004. It provides students and teachers the opportunity to videoconference with two-way audio and video with an education specialist at NASA. It enhances NASA's capability to link students and educators with NASA experts (Loston et al; 2005). The NRC report on NASA's Education Programs states an area of improvement in its "weak standards for assessing the educational merits of the modules" (National Research Council, 2008. P. 72). It goes on to recommend that future project reviews to include "focus on the educational merits (effective pedagogy)…" (National Research Council, 2008, p. 72). Since this project is fairly new, there is not much research available specific to NASA's DLN. The DLN modules are written in the 5E model. From August 1, 2009 to July, 2010, the "Can A Shoebox Fly? Challenge" was conducted 68 times for Part I (students learn about aircraft design and are issued the challenge) and 65 times for Part II (students conduct formal presentations of their gliders) nationwide.

Student Attitudes

It has been intriguing to researchers how science attitudes and achievement are correlated. In order for a student to learn science, research has without fail shown that attitudes and interest in science is important for learning to occur even though much more attention has been focused on scientific literacy and comprehension of the scientific method. The mounting decline in interest in science has affected the number of student pursuing STEM careers. As adults, their attitude will influence their support or opposition on political issues. In fact, Novodorsky (1993) discusses this issue and states that when the students have positive attitudes towards science, the likelihood that students will become "scientifically literate adults who will be able to make rational decisions about science-related issues" (pg. 27). George's research report in the International Journal of Science Education, lists several influences on the student learning process. These influences come from teachers, self-concept, parents, peers, achievement motivation, science anxiety, and gender (George, 2006). This study concluded that when self-concept is high, there are higher attitudes toward science. Teachers were the next strongest indicator of student attitudes on science (George, 2006).

In Hsieh, Cho, Shallert, and Liu's (2008) study, the results indicated a "strong positive relationship between students' self-efficacy and student achievement in a technology-rich, self directed environment" (p. 46). And Akinoglu and Ozkardes (2007) observed in a study conducted on inquiry problem-based learning "a positive change in the attitudes of the research group students towards science class" (p. 77). Components of a good science class include hands-on inquiry activities and thus should play a part in influencing student attitudes (Osborne, 2003).

Numerous studies have been conducted to examine the correlated relationships between science attitude and achievement in science and have found, in fact, that one does influence the other. (Castsambis, 1995; Reynolds & Walberg, 1992; Simpson & Oliver, 1990; Stienkamp & Maehr, 1983; Wilson, 1983). Fleming and Malone (1983) conducted a meta-analysis of the research that studied grades K through 12, from 1960 to 1983. They concluded that "as age increases, the relationship with achievement increased and with attitude decreased" (Sorge, 2007; pg.33) Oliver (1986) conducted a longitudinal study on attitude toward science, achievement motivation, and science self concept as predictors of achievement. He concluded that "attitude toward science and achievement motivation were significant predictors of achievement for some levels of science students" (p.ii). Perkins, Adams, Pollock, Finkelstein, and Wieman (2004) found that students who have more favorable attitudes are more likely to have higher achievement. In their study, the authors found a positive correlation between science attitudes and conceptual learning gains.

Some studies have even studied the effects of gender and science attitudes and achievement. Sorge (2007) researched science students from age 9 to 14 in New Mexico.

She assessed the differences in attitudes to science and found a significant relationship between age and attitude toward science where the students' attitudes decreased between the elementary and middle school transition (science attitude mean scores: Ages 9-11 = 4.84, standard deviation =1.07; Age 12-14= 3.73, standard deviation = 1.35). Catsambis (1995) examined gender differences in attitudes and science achievement with middle school students. Her findings showed that middle school females are not lagging behind their male peers in science achievement but they do have less positive attitudes toward science and have less aspiration to enter into a science career than their male classmates. Weinburgh (1995) conducted a meta-analysis of literature of gender differences in student attitudes towards science and correlations between science attitudes and science achievement. She examined 18 studies and found the correlation was positive for both males and females but it was stronger for females in both biology and physics. Kelly (1981) offers a hypothesis that females are not high achievers in science because they have less favorable attitudes towards science than males.

Distance Learning/E-learning/Videoconferencing

Today, the education systems are being pushed to prepare students for the 21st century. Students nowadays will have jobs that have not even begun to be needed and yet school must prepare them to be able to interact with an interdependent world with new technologies, global cultures, politics and economies. The term "digital native" has been used to describe such students and the challenge is to teach them how to think as well as be able to apply that knowledge in an ever-changing world.

With the fast moving advancement of technology, more and more students are learning via distance learning. There is a need for lifelong learning and distance learning provides that opportunity for many who may not have had access to learning prior to this technology. NASA's Digital Learning Network videoconferencing provides opportunities for students to present authentic research and findings to obtain feedback from NASA personnel.

Much research has been conducted on learners' reactions to distance learning. A survey conducted by Barron (1987) of college-aged students taking distance education courses found that these students preferred to be in a traditional classroom. Other studies have reported that students felt less focused in distance education classes than in traditional classes (Barker & Platten,1988; &Wolfram, 1994). Yet, other studies contradicted this. Egan et al (1992) reported no significant differences in student interest between a distance education class and a traditional classroom.

Ingebritsen and Flickinger (1998) conducted a study on science courses delivered through distance learning. This study found that grades of students who took the course over the internet were slightly higher than face-to-face classes as well as favorable attitudes towards the internet course (Ingebritsen, 1998). And the purpose of another study by Kenny, Bullen, and Loftus (2006), was to "investigate the existence and nature of student problem formulation and resolution processes in an undergraduate on-line PBL (problem-based learning) course in agriculture science" and concluded that PBL on-line can foster problem solving behaviours (sic) (p. 2).

A study was conducted by Glenn (2001) comparing students enrolled in on-campus versus distance education in a political science class and compared learning outcomes. Glenn (2001) states an "advantage of distance learning is that more students can be educated at a specific investment level than can students in a traditional environment because instructors can teach in multiple classrooms (p. 5). She concludes that there is “no statistically significant differences exist in the pre-test performance between the students who completed political science courses on campus” (Glenn, 2001, p. 70) and that there was “no statistically significant difference in student perceptions.” (Glenn, 2001, p. 21)

Videoconferencing provides opportunities for students to present authentic research and findings and to obtain valuable feedback from peers, scientists, etc. Wiske (2005) states “videoconferencing allowed students to present their findings in compelling ways that led to important civic actions both in their own community and in distance places” (p. 50) Agreeing with Wiske, Boone (1996) states “science education should expand its use of distance education technology,” and goes on to say “this technology seems to be one way in which more individuals of all ages can be exposed to science” (p. 45).

CHAPTER III

DESIGN AND METHODOLOGY

Introduction

This study utilized a mixed method approach to data collection from secondary science students. The methodology used during this research helped determine whether using NASA's Digital Learning Network (DLN) module, "Can A Shoebox Fly? Challenge," could improve science attitudes toward science and interest in STEM careers. The quantitative data was collected from a pre- (Form A) and a post- (Form B) science attitudes survey completed by the subjects. The qualitative data was gathered from face-to-face interviews with the subjects as well as student composition notebooks. The subjects were sixth through ninth grade students enrolled in a science class in the Kadoka Area School District. The researcher chose NASA's DLN "Can a Shoebox Fly? Challenge" for several reasons. One, most of these students had not been exposed to the subject of aeronautics thus, minimal prior knowledge was known. Two, the students were able to experience the engineering design process by designing, testing, redesigning, retesting, etc, which leads to learning by the constructivism approach. Third, the researcher enjoyed the module because of her interest in aviation. The researcher's purpose was to determine whether NASA's DLN was a viable delivery method to increase student attitudes towards STEM – specifically, science. This research project was approved by Oklahoma State University Institutional Review Board (Appendix B).

Explanation of the Research

Research Questions and Purpose

The purpose of this study is to assess the degree to which NASA's Digital Learning Network (DLN) will promote scientific attitudes in the secondary science classroom in South Dakota. This research will be used to ascertain if the secondary students participating in a DLN event will promote a more positive attitude toward science.

This information will be used to determine the if the Shoebox Challenge will create a change in attitude in students in science, as well as, inspire the next generation of explorers to pursue STEM careers. It will also be used to determine if a need exists to modify the DLN modules to be more effective to promote scientific attitudes.

Research Questions

1. To what extent will the DLN module "Can a Shoebox Fly? Challenge" promote scientific attitudes in the secondary science curriculum?
2. Is there a gender difference in science attitudes with regards to "Can a Shoebox Fly? Challenge?"
3. How effective the DLN is with regards to student interest in STEM careers?

4. Does a need exist to modify the DLN module "Can a Shoebox Fly? Challenge?"

For research question one, the null hypothesis is that there will be no differences in students' scientific attitudes (H_0: pre=post). For research question two, the null hypothesis is that student population who participated in the DLN events will have no difference in gender (H_0: male= female).

Research Context

The participating subjects were enrolled in a secondary science class from Kadoka Area High School (grade 9) and Kadoka Elementary School (grades 6-8). Both schools are located at the same address in Kadoka, South Dakota. The Kadoka Area School District covers over 2000 square miles in South Dakota and most of the community economics involve farming, ranching, and tourism (Kadoka is located at the edge of the Badlands National Park). The district employs approximately 80 staff members and 350 students (2009-2010 school year) students attend the district schools. There are 3 elementary schools (Pre-K through 8th grade) and one high school (grades 9-12). Kadoka Area School District is a NASA Explorer School. They are one of 26 schools/school districts chosen in 2006 to participate in a 3-year partnership with NASA. The agreement between NASA and the district included $17,500 in technology grants, professional development workshops for teachers, an increase in family/community involvement, and student classroom visits to increase students' skills in STEM. The NASA Explorer Schools project chose schools, through an application process, based on underserved populations in diverse geographic locations. Both participating schools are

Title I schools. Title I is funded by the U.S. Department of Education to “help ensure that all children meet challenging state academic standards” (U.S. Department of Education, p. 4) in “public schools with high numbers or percentages of poor children “(U.S. Department of Education). Title I eligibility is determined by how many students are enrolled in the free and reduced lunch programs – 40% or greater. In the 2008-2009 school year, Kadoka High School had the following students eligible for the free or reduced lunch program: 31 students in ninth grade, 18 students in tenth grade, 23 students in eleventh grade, and 17 students in twelfth grade. At the elementary school, ninety-three (93) students are eligible for the free lunch program and there are no students eligible for a reduced-price lunch.

There are 89 total students (31 in 9th grade) enrolled in Kadoka High School where the demographics are 40 male and 49 female students:

51	Caucasian students
37	Native American students
1	Asian/Pacific Islander students
0	African American and Hispanic students

Kadoka Elementary School has 203 total students with only 63 in grades 6-8 (22 in the sixth grade, 23 in seventh grade, and 18 in eighth grade). The demographics for the entire school are 107 male and 96 female students:

100	Caucasian students
102	Native American students
1	Asian/Pacific Islander
0	African American and Hispanic students

Population

The population of this study is ninety-four students in 6th-9^{th} grades. There are fifty-five subjects in the sample. The subjects were selected based on their grade level and that they were enrolled in a science class. All of the subjects in grades 6-9 were required to participate in the “Can a Shoebox Fly? Challenge” as part of their regular class, but were not required to participate in the research and data collection; however, all of the students volunteered and signed a student consent form (see Appendix B) Parental/Adult consent was obtained by permission forms as well as consent from the Principal of the Kadoka Area Schools. Even though all of the parent/adult and students consented, only 55 students were actually able to participate in both the pre- and post-science attitudes survey due to absences from school or other obligations during school hours, that is, sports or band competitions. The students in this study have had little to no exposure to NASA’s DLN modules but have been exposed to NASA’s educational curriculum in the classroom by their teachers as well as the Aerospace Education Specialist in the Aerospace Education Services Project.

The demographics of the sample are:

6^{th} grade = 21 students – 12 female and 9 male
7^{th} grade = 6 students – 4 female and 2 male
8^{th} grade = 18 students – 8 female and 10 male
9^{th} grade = 10 students – 6 female and 4 male

No other demographic information was obtained.

Treatment

Parent/Adult and student consent forms were sent home the week before Form A of the science attitudes survey was administered. Permission from the Principal was obtained verbally at first, then via email (see Appendix A). Form A of the science attitudes survey was given to the students a few days prior to the first Digital Learning Network (DLN) event. The surveys were given during the subjects' science classes. Form A of the science attitudes survey assessed the subject's initial attitudes towards science.

Depending on when the first DLN event was scheduled, the students participated in NASA's DLN "Can A Shoebox Fly? Challenge" two or three days after Form A of the attitudes survey was administered. Students were brought, during their science class, to the classroom where the videoconferencing equipment was housed and used for other distance learning classes. The teachers were in this classroom during the events as observers and the researcher was present to facilitate the events. The researcher explained to the students what they were about to experience and how to use the microphones so they could ask and answer questions of the DLN Education Specialist. Each DLN event was approximately one hour in duration in which the DLN Education Specialist showed the students videos of NASA's Helios airplane and a model airplane wing in a water tank to demonstrate to the students how the shape of the airplane wing affects aerodynamics. The DLN Education Specialist asked the students questions regarding the videos such as "why do you think NASA is using solar energy to power an airplane?" The students also constructed a "wing-on-a-string." Students used 8.5"x11" paper, tape, a straw, and string to construct a paper model of a glider wing (see Appendix F). In this hands-on activity, students were to experience how Bernoulli's Principle is applied to the design of an airplane wing to create lift of an airplane or glider. The students were given the opportunity to ask questions of the DLN Education Specialist as well as the researcher. Each student was given a composition notebook, provided by the researcher, to record data, changes made to their gliders, results obtained because of these changes, glide slope ratio of the glider, as well as any other pertinent research data. The students were presented the design challenge to build a glider out of an ordinary shoebox. The students were given criteria and constraints to their design to simulate what occurs in real-world engineering applications. The criteria were:

a. The glider must move forward at least three meters
b. The glider must demonstrate an effective positive glide slope ratio
c. The glider must not break upon landing
d. Teams/Individuals will prepare a final presentation of results and understanding.

The constraints were:

a. The glider must include an in-tack shoebox in its design
b. The glider must be built out of recycled materials
c. Time limit of one month to research, build, and test the glider

Four weeks later the students participated in a second DLN event, where they presented their gliders and their results to the researcher and the DLN Education Specialist. Some students presented their gliders individually and others designed their gliders in teams of 2 or 3. Each glider was held in front of the DLN camera and the students described what materials they used, what changes/modifications that were made, the student's thinking behind these changes, and their results. (Example: how did the glider fly and what was the glide slope ratio). Each DLN connection was approximately one hour in length. Immediately after the second DLN connection, Form B of the science attitudes survey was administered and collected by the science teacher. The students' composition notebooks were also collected, graded by the teacher, and mailed to the researcher at a later date. After each of the second DLN events, the researcher conducted face-to-face interviews with the students. Twenty-two of the students were chosen based on their willingness to be interviewed (i.e. the students volunteered to be interviewed). The researcher asked the following open-ended questions to each interviewee:

a. Did you like learning through the Digital Learning Network? Would you prefer learning with a teacher in the room or with the DLN?
b. What part of the "Can a Shoebox Fly? Challenge" did you like?
c. What part of the "Can a Shoebox Fly? Challenge" did you not like?
d. What was the hardest part of the "Can a Shoebox Fly? Challenge"?
e. Would you want to do the "Can a Shoebox Fly? Challenge" again? Why or why not?
f. What career field do you think you want to pursue after high school or college?

During the second day of the second DLN connection, the school held a Family Night. This allowed the parents, siblings, and community members to view the shoebox gliders and to see them fly.

<u>Instrument Used</u>

Quantitative Method: The instrument used is a 36-question survey using Novodvorsky's science attitudes survey. This instrument uses a Likert-5 scale with respondent choosing one of the responses from strongly disagree to strongly agree. The reliability coefficient of this instrument is 0.93 and the construct validity is 0.82 (Novodvorsky, 1993).

Permission was obtained to use the science attitudes survey (see Appendix E). Form A and Form B (see Appendix D) are parallel forms of each other and contain questions that attempts to determine students' attitudes towards science. This allowed for a test-retest format and was designed to reduce "problems arising from respondents remembering items from one administration to the next" (Novodvorsky, 1993, p. 51).

Each survey allowed for the questions to be grouped based on three factors identified by Novodvorsky. These factors are:

1. Interest in science classes and activities in science class
2. Confidence in ability to do science
3. Interest in science-related activities outside of school

Examples of questions for each factor are:

Factor 1 – Form A: I am fascinated by what I learn in science class
Form B: I do not want to study any more science
Factor 2 – Form A: I enjoy the challenge of science class
Form B: I have the ability to be successful in science class
Factor 3 – Form A: I like to share what I've learned in science class with my friends and family.
Form B: I enjoy reading about science in the newspaper or magazines.

Form A Science Attitude Survey: Form A science attitude survey was emailed to the two science teachers in grades 6-9. Instructions were sent to the teachers by the researcher to read to participating students (See Appendix C). These teachers administered and collected Form A science attitudes survey from their students during science classes. The students were instructed to check whether they strongly agreed, agreed, neither agreed or disagreed, disagreed, or strongly disagreed with the corresponding statement on the science attitudes survey.

Form B Science Attitude Survey: Form B science attitude survey was administered and collected by the same teachers immediately after the completion of the second DLN event. The students were again instructed to check the appropriate box of strongly agreed, agreed, neither agreed or disagreed, disagreed, or strongly disagreed with the corresponding statement on the science attitudes survey.

Both Form A and Form B science attitudes surveys used a Likert-5 scale with ordinal responses of strongly agree, agree, neither agree or disagree, disagree, or strongly disagree. The positively worded questions received a score based on strongly agree = 5, agree = 4, neither agree or disagree = 3, disagree = 2, and strongly agree = 1. Negatively worded items received a science of strongly agree = 1, agree = 2, neither agree or disagree = 3, disagree = 4, strongly disagree = 5.

Qualitative Methods

Composition Notebooks

All of the students in a science class participated in the "Can a Shoebox Fly? Challenge" as part of their science curriculum. This involved them keeping a composition notebook to record their data, design changes, and results of flight based on these changes. The notebooks were submitted by the students to their science teacher to be graded. After the teachers graded the notebooks, the participating students' notebooks were returned to the researcher for insight on their learning process and their interest in STEM careers. Twenty-six notebooks were returned to the researcher. These notebooks represent forty-nine students because some of the students worked in groups and submitted one notebook per group.

The researcher reviewed the notebooks for evidence of learning and the inquiry process. The indicator of this evidence is the engineering design process.

Interviews

The researcher conducted face-to-face interviews with twenty-two students. The demographic breakdowns of these students are:

6th grade = 6 students –	1 female and 5 male
7th grade = 6 students –	3 female and 3 male
8th grade = 6 students –	2 female and 3 male
9th grade = 5 students –	2 female and 3 male

All of the students and parents/adults gave consent to be interviewed but ultimately, it was the students who volunteered to be interviewed. The interviews were conducted on the day of their final second DLN event but only after the DLN event occurred.

The students were interviewed in a quiet room by themselves in hopes of obtaining honest answers without undue influence from their peers. Each interview lasted approximately 20 minutes. The interviews were not audio nor video taped so the researcher hand recorded the students' responses. The researcher asked for their four-digit number used on their science attitude surveys so that the researcher could correlate the interviews with the notebooks and attitude surveys if needed. The researcher asked the following questions to each of the interviewees in the same order:

1. Did you like learning through the Digital Learning Network? Would you prefer learning with a teacher in the room or with the DLN?

2. What part of the "Can a Shoebox Fly? Challenge" did you like?

3. What part of the "Can a Shoebox Fly? Challenge" did you not like?

4. What was the hardest part of the "Can a Shoebox Fly? Challenge"?

5. Would you want to do the "Can a Shoebox Fly? Challenge "again? Why or why not?

6. What career field do you think you want to pursue after high school or college?

Students were interviewed to obtain their description about their DLN experience, their learning, and their attitudes towards STEM careers.

Data Collection

All of the students who participated chose a four-digit number that they could remember to allow for test-retest correlations. Anonymity was maintained because the researcher did not collect names and the four-digit number to prevent anyone to be able to identify specific students. Fifty-five students completed both Form A and Form B of the science attitudes survey. The data collected during this research included Form A (pre-) science attitudes survey, Form B (post-) science attitudes survey, the researcher's notes from the face-to-face interviews and the subject's composition notebooks which contained their glider research and data. The parent/adult consent forms, the student consent forms, composition notebooks, and attitude surveys were kept locked in the researcher's home safe.

Limitations of the Study

The limits of generalizability of this study is the relatively small sample population. The researcher cannot be sure that the findings would extend to the other sixth through ninth grade students in South Dakota and across the nation. The researcher also cannot make generalizations about the rest of NASA's Digital Learning Network's event catalog as to whether student science attitudes increase after participating in a DLN event, if there is a gender difference, and a change in career choices will occur.

Furthermore, there were unexpected limitations. All of the 94 students in grades 6-9 were not able to participate in the research. This was due to various reasons ranging from absent on the day(s) the DLN event occurred to non-attendance in science class because of other obligations during school hours (sporting events and band competitions).

Another unexpected limitation was the non-compliance of students submitting their notebooks. While it was not mandatory to participate in the research, all of the students and parents signed the consent forms. It was mandatory that the students participate in the "Can A Shoebox Fly? Challenge" since it was part of their curriculum to receive a grade from their teacher.

The students volunteered to participate and it is assumed the students answered the survey questions and interview questions honestly.

Data Analysis

Because of the large number of variables contained in the data, a Principal Component Analysis (PCA) was performed on the science attitudes surveys. PCA is a method that reduces the number of data dimensionally by performing a covariance analysis between factors and is a tool to uncover unknown trends in data (Jolliffe,2002, p. ix) PCA explores correlations between samples. There are 79 variables, which represent the students' four-digit number, gender, grade level, 2 unused flags (notebooks and interviews), responses from 36 questions from Form A science attitudes survey and responses from Form B science attitudes survey. These variables were Likert-5 variables, that is, ordinal responses with five possible values. These variables have the same direction (5 was most positive interest to science, 1 most negative interest towards science). A paired t-test would be inappropriate because the number of questions corresponding to each factor differed from Form A and Form B. Furthermore, the number of questions for each group changed. A single paired means test for each of the three groups would also not be appropriate since a normal distribution is not supported by the data.

A paired means test on a latent variable was chosen. The researcher grouped the attitudes survey questions into three factors and is implicitly stating that there is an unmeasured variable that represents a student's interest in science and a standard way of acquiring that latent variable is to perform PCA. The three factors are:

Factor 1 - Interest in science classes and activities in science class

Factor 2 - Confidence in ability to do science

Factor 3 - Interest in science-related activities outside of school

A minor barrier to this method is the PCA theory is based on an assumption that the measures are continuous; however, Kelenikov and Angeles (2009) indicate that estimating the correlation between two theorized normally distributed continuous latent variables is only slightly better than treating the ordinal data as continuous (p. 135). Thus, the Likert-5 variables are treated as being a continuous measure of interest towards science.

Form A		
Factor 1	Q2, Q6, Q9, Q11, Q21, Q26, Q27, Q30	8
Factor 2	Q3, Q7, Q12, Q17, Q20, 22,Q28	7
Factor 3	Q8, Q10, Q13, Q14, Q16, Q23, Q24, Q25, Q29	9

Form B		
Factor 1	Q1, Q6, Q9, Q13, Q21, Q22, Q25, Q27, Q30	9

Factor 2	Q5, Q11, Q12, Q14, Q15, Q16, Q17, Q18, Q23, Q26	10
Factor 3	Q2, Q3, Q4, Q7, Q10, Q19, Q20, Q24, Q28	9

As previously stated, Factor 1 is general interest in science classes and activities in science class; Factor 2 is confidence in ability to do science; and Factor 3 is interest in science-related activities outside of school. Each question in the science attitudes survey was broken out into their respective factor and a PCA was performed to determine if there existed an underlying variable that summarizes the feelings behind the responses and determine the subjects' overall underlying feelings towards science.

To compare pre- (Form A) and post- (Form B) tests, a paired t-test was performed and its null hypothesis H_0: pre=post. To compare male and female results, and independent t-test was performed where its null hypothesis Ho: male=female.

Summary of Chapter

This study employed a mixed method approach to determine if secondary science students in a South Dakota school district improved their attitudes toward science and career choices changed after participating in NASA's Digital Learning Network's "Can a Shoebox Fly? Challenge."

Quantitative data was collected from 55 students using pre-and post- science attitudes surveys. Due to the high number of variables, it was determined that performing Principal Component Analysis was the best analysis to be conducted. A Principal Component Analysis was performed on each of the three factors as well as an overall factor on the students' underlying interest towards science. Calculations were also performed comparing pre- and post- scores and comparing gender.

Qualitative data was collected through face-to-face interviews with twenty-two students – six 6th graders, six 7th graders, five 8th graders, and five 9th graders. The interviews were conducted to obtain their descriptions about their DLN experience and their attitudes towards STEM careers. Twenty-six composition notebooks were collected, which represents 49 students, and the notebooks were reviewed for their evidence of learning and the inquiry process.

CHAPTER IV

FINDINGS

Introduction

This chapter examines the findings of this study that assess students' attitudes towards science who are in grades 6-9, before and after participating in NASA's Digital Learning Network's "Can A Shoebox Fly? Challenge." The results are organized into two sections to reflect a mixed-methods approach described in Chapter III. The first section comprises the quantitative data that was collected from the fifty-five students using a pre and post science attitudes survey. The second section constitutes the qualitative data collected through twenty-six students' composition notebooks as well as face-to-face interviews with twenty-two students.

The following research questions are answered with the findings prescribed in this chapter:

1. To what extent will NASA's Digital Learning Network's "Can A Shoebox Fly? Challenge" promotes scientific attitudes in the secondary science curriculum?
2. Is there a gender difference in science attitudes with regards to "Can A Shoebox Fly? Challenge?"

3. How effective is NASA's Digital Learning Network with regards to student interests in STEM careers?
4. Does a need exist to modify the DLN module "Can A Shoebox Fly? Challenge?"

Quantitative Findings

Quantitative data was collected from fifty-five students using pre (Form A) and a post (Form B) science attitudes surveys. A Principal Component Analysis (PCA) was preformed to reduce the number of observable variables into principal components – a smaller number of variables that will account for the variance in the 79 observable variables. In each of the cases, the first PCA score accounted for the lion's share of the variance in the variables; therefore, the first score serves as an excellent substitute for several variables.

To compare Form A and Form B test scores, a paired t-test was performed. This variety of the t-test has its null hypothesis H_0: Form A=Form B. The t-test assumes Normality of the underlying scores, but is not as sensitive to this assumption as in the ANOVA. Shapiro-Wilks tests of Normality can be used to determine whether the distribution's deviation from Normality is of concern. In none of the cases was the distribution of the PCA score so far from Normal that it endangered the conclusions of the t-test.

An independent t-test was used to compare the male and female results. This t-test has its null hypothesis H_0: male=female. Also, there is no assumption of equal variances in the two groupings (male vs. female). This test assumes Normality of the underlying scores and is not as sensitive to this assumption as the ANOVA. The conclusions are safe since none of the t-statistics were close to the significance boundary.

General Science

The PCA variable took care of 94.0% of the variance in the pre-survey (Form A) and 93.8% of the variance in the post-survey (Form B) variables which indicated the variables are important latent variables common to all of the questions and it measures the students' interest towards science in general.

When comparing the scores for all students taking the survey, the difference is statistically significant at the alpha=0.05 level ($t=4.8821$; $df= 44$; $p<0.0001$) indicating that the students has a positive change after completing NASA's Digital Learning Network's "Can A Shoebox Fly? Challenge" than before it.

When examining the data based on gender, the results show that both males and females exhibited a positive change in attitudes after completing the "Can A Shoebox Fly? Challenge" than before it. (Males ($t=2.7495$; $df = 19$; $p= 0.01275$) and females ($t=0.1596$; $df = 35.611$; $p = 0.8741$)). Furthermore, there is no evidence that the male students exhibited more change that the female students ($t=0.1596$; $df = 35.611$; $p = 0.8741$) These results are robust to violations of Normality.

The questions from the science attitudes survey are grouped into three factors:

Factor 1: Interest in science classes and activities in science class.

Factor 2: Confidence in ability to do science.

Factor 3: Interest in science-related activities outside of school.

Form A		
Factor 1	Q2, Q6, Q9, Q11, Q21, Q26, Q27, Q30	8
Factor 2	Q3, Q7, Q12, Q17, Q20, 22,Q28	7
Factor 3	Q8, Q10, Q13, Q14, Q16, Q23, Q24, Q25, Q29	9

Form B		
Factor 1	Q1, Q6, Q9, Q13, Q21, Q22, Q25, Q27, Q30	9
Factor 2	Q5, Q11, Q12, Q14, Q15, Q16, Q17, Q18, Q23, Q26	10
Factor 3	Q2, Q3, Q4, Q7, Q10, Q19, Q20, Q24, Q28	9

Each factor was broken out into their own group and a PCA was performed on that group to determine if there existed an underlying variable that summarizes the feelings behind the responses.

Table 1 – Summary of Form A and Form B Attitudes Survey Analysis

Factor	**Overall t**	**Overall df**	**Overall p**
Factor 1 – Interest in science class & activities in science class	4.6382	44	significant
Factor 2 – Confidence in ability to do science	9.9946	44	significant
Factor 3 – Interest in science-related activities outside of school	4.4752	44	significant
General Science – overall interest in science	4.8821	44	significant

Factor 1

There is high confidence that the PCA scores (Form A = 96.6% and Form B = 95.5%) measure the underlying attitude of the students' interest in science class and activities in science class. The results for Factor 1 are similar to that for General Science and there is strong statistical evidence that students have a positive change towards Factor 1 (Interest in science classes and activities in science classes) after completing the "Can a Shoebox Fly? Challenge" than before ($t= 4.6382$; $df = 44$; $p<0.0001$). This difference was felt by both males ($t=3.3837$; $df = 19$; $p=0.003117$) and females ($t=3.142$; $df = 19$; $p=0.004418$); however, the differences between genders are not statistically significant ($t=0.7832$; $df = 37.51$; $p=0.4384$).

Factor 2

There is high confidence that the PCA scores (Form A = 94.1% and Form B = 94.6%) of the variance measures the attitudes of the students' confidence in ability to do science. The results for Factor 2 are similar to those for General Science and Factor 1 and there is strong statistical evidence that students had a positive change towards Factor 2 (confidence in ability to do science) after completing "Can a Shoebox Fly? Challenge" than before ($t=9.9946$; $df = 44$; $p\ll0.0001$). The difference was felt by both males ($t=5.901$; $df = 19$; $p\ll0.0001$) and females ($t= 8.1018$; $df = 24$; $p\ll0.0001$). Additionally, the difference between the genders was not statistically significant ($t=0.7437$; $df = 39.859$; $p = 0.4614$).

Factor 3

There is high confidence that the PCA scores (Form A = 93.5% and Form B = 92.8%) of the variance measures the underlying attitudes of the students' interest in science-related activities outside of school. There is a statistically significant relationship between Form A and Form B but, unlike Factor 1 and Factor 2, it is in the opposite direction of the hypothesis. Thus, there is strong evidence that the "Can a Shoebox Fly? Challenge" caused the attitudes of the students toward this factor to decline ($t=4.4752$; $df = 44$; $p<<0.002114$). The conclusion also holds when the assumption of Normality is relaxed and the test is replaces with the Mann-Whitney test. This conclusion holds for males ($t=2.851$; $df = 19$; $p = 0.01022$) and for females ($t=3.4443$; $df = 24$; $p = 0.002114$). Finally, the data suggested no appreciable difference between male and female students ($t=0.2832$; $df = 36.324$; $p=0.7787$).

Reliability

Since Novodvorsky's survey reliability was based on high school student responses and the researcher used Novodvorsky's survey with middle school students (6th-8th graders) as well as high school students (9th grade), a Chronbach's alpha was calculated for each of the Factors to measure the internal reliability.

Table 2 – Chronbach's Alpha for Factors on Attitudes Survey

Factor	Form A alpha	Form B alpha
Factor 1 – Interest in science class	0.8594	0.7596
Factor 2 – Confidence in ability to do science	0.7598	0.7172
Factor 3 – Interest in science-related activities	0.6637	0.7472
Overall	0.8884	0.8821

Qualitative Findings

Twenty-six composition notebooks were returned to the researcher. Even though twenty-six notebooks were returned, they actually represent forty-nine students because some of the students worked in groups and returned one group notebook instead of individual notebooks. The researcher reviewed each notebook for evidence of student learning and chose student notebooks based on the amount of detail documentation of their engineering design process via the 5E inquiry learning model of "Can A Shoebox Fly? Challenge."

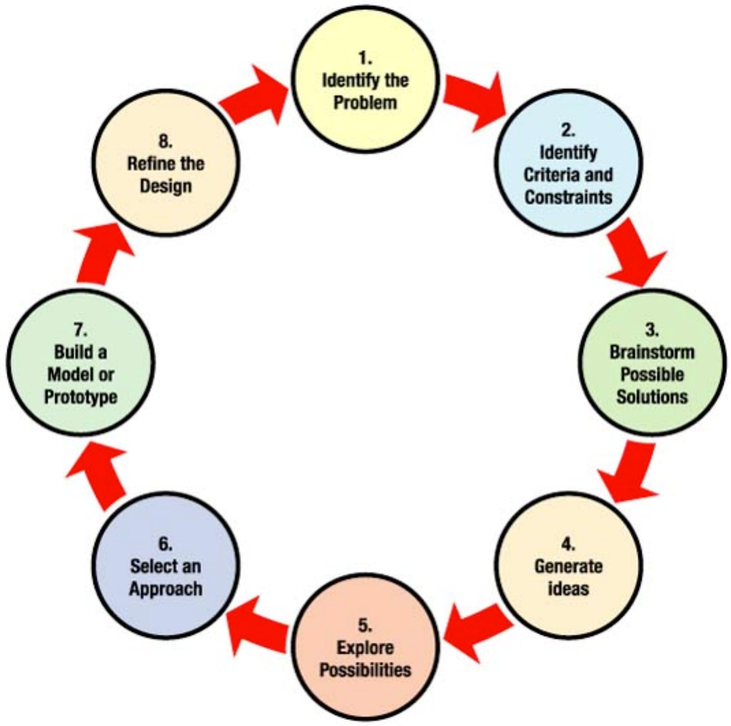

Figure 1 – Engineering Design Process

Students documented in their notebooks the learning and thinking behind building designing the gliders. Although they didn't specifically state which steps in the Engineering Design Process are used, the researcher was able to determine the steps based on the students' notes. Excerpts from students' notebook are below and are offered as evidence of learning through inquiry using the engineering design process through the medium of "Can A Shoebox Fly? Challenge." The students begin by defining the problem (converting a shoebox into a glider) and taking a vague idea and brainstorming possibilities given the criteria and constraints. The students then begin to research and construct prototypes and as they test and re-examine their designs, and produce a more robust design, they are engaged in learning.

Day 1 **(*** indicates the same student as the interviews)

6th grade female #1* - **"worked on it and it was terrible I gess [sic] I was in a hurry but I made it with cardboard with an OP box and with a telephone [sic] book front page…."**

6th grade female #2 - ***" …I ripped off the top of the shoebox so that when it is gliding, it will go farther because of the less weight….I tested how far the shoebox can glide by itself so that I can see if the wings will help it go farther. It goes about 3 or 4 feet by itself."***

6th grade female #3 **– "Put a little Styrofoam ball in a paper and shaped it was a cone and glued it to the front; glued popsicle sticks too and put them around the cone"**

6th grade female #4 **– *"started on box – put wings on"***

6th grade female #5 **– *"went over plans for construction; used cone for a nose; using paper plates for wings"***

6th grade female #6 **– *"got a shoebox; planned out what to do; cut the wings and tail wing"***

6th grade male #1 **– *"we put a half-cut bottle for the nose of the shoebox then put two half-cut cans for the tail"***

6th grade male #2 – ***"got box and objects for glider – paper, scissors, box parts for wings, glue"***

6th grade male #4* - ***"first, I tried to see if the lid affected the aerodynamics; the lid fell off while it was flying; I tried to see if it would fly better without the lid- it went a little farther."***

7th grade female #2*** - "researched gravity – make as light as possible; lift – make good wings with camber; to reduce drag – streamlined glider (narrow nose and tail and wings that don't stand straight out; thrust – creative – no motor"***

7th grade male #1* - ***"the glider was built and tested; thrown then caught as contact with ground"***

8th grade female #1* – ***"We cut holes in the side of the box so we could put the wings in; we put the nacho trays as the wings; once we got the wings in, then we colored them."***

8th grade female #2* - ***"Spray painted the top of our box black; spray painted the bottom red"***

8th grade female #3 – **"Decided to reinforce the wings with second layer out of a cake pan; decided to have smaller wings (cake pan wings) on top of shoebox and larger cardboard wings on the bottom with straws supporting the wings in between."**

8th grade female #4 – ***"examined the box; light foil cake pan (wings); covered the box with wrapping; decided to use a whole b-day instead of a cut one; covered the b-day hat (for nose) with b-day paper"***

8th grade female #5 – ***"chose a rectangular red shoe box; planning on creating nose cone today; wings need work – used a long piece of cardboard punched through shoebox wall…."***

8th grade male #1* - ***"we got the tablets and rulers but we didn't get started on the project yet; we got instructions on the project we were supposed to make a shoebox fly."***

8th grade male #2* - ***"the wings: a. get three willow saplings; b. measured for the right length; c. shave them down to fully balanced; d. used the three willow saplings to make a curve shape for the wing; e. used fishing line to bring the tips of the wings up; f. used plastic material for the wings because it is light weight and doesn't teer[sic] easily; g. I used the Bernoulli's principle for the wings and nose and with the tail"***

8th grade male #3 – ***"we worked on plans for the 3 main parts. We made the cone, and we were done for the night."***

8th grade male #4 – ***"we are gunna[sic] cut a bottle top off and make it connected to the box so it it more arrowdinamic[sic] and make the top of the box as wings"***

8th grade male #5 – ***"I started thinking what I was going to do. I got started on my shoebox. I cut my box where my wings were going to go. I first put cardboard on the bottom to see how that would work – it didn't. Then I tried Styrofoam and that made it to [sic] heavy. I tried tag board to see how that would make it fly – it went far but then it dropped like a duck. "***

8th grade male #6 –see responses from 8th grade male #1 (shared a notebook)

9th grade female #1 - ***"Went to the dump and picked up some foam for the wings; shaped aerodynamic wings with a curry comb."***

Unknown #1 **–** ***"spray painted the top of our box black; spray painted red"***

Unknown #2 **–** ***"I got a pink square shaped box to make my glider. Also, I have two decent wings on each side that has some writing on them. A tail that is on top of my glider. Two triangles on each side of my box."***

Unknown #3 **–** ***"Worked on the base of my airplane, and the sides, front, and back"***

<u>Day 2</u>

6th grade female #1* - **"worked on it. Hopefully it was good"**

6th grade female #2 - ***"Today, I put on the wings and tested how far it can go, which was not very far. So I thought of what might help. I came up with a tail to keep it balanced. Once again, it failed and I'm currently thinking of what to do….I thought if I added a small pair of wings to the tail, it will help it glide instead of crash. So, I sketched out a design and tested it on another shoebox and it works!"***

6th grade female #3 **– "we put paper around and taped the edges and tip. Had paper to put on the sides for decoration for the box. Figured out how to make wings and tail."**

6th grade female #4 **–** ***"put on tail – restarted tail"***

6th grade female #5 **–** ***"put new and longer wings on; made it more aerodynamic"***

6th grade female #6 – ***"taped wings and tail to box; tested it – it tumbled and fell head over head forward; put a tube threw[sic] the middle to make it go farther; tested – flew great"***

6th grade male #1 – ***"put a Styrofoam wing. The shoebox name is Black Hawk; 23 feet when we tested it. Flew perfect. You can't throw it to hard or the nose will go down."***

6th grade male #2 – ***"made wings and nose for glider; making tail right now"***

6th grade male #4* - ***"Next, I cut out 2 pieces of cardboard and taped then to each sides of the front of the box. I made the two ends touch so it forms an arrow; better already"***

7th grade female #2***** - student drew out glider design

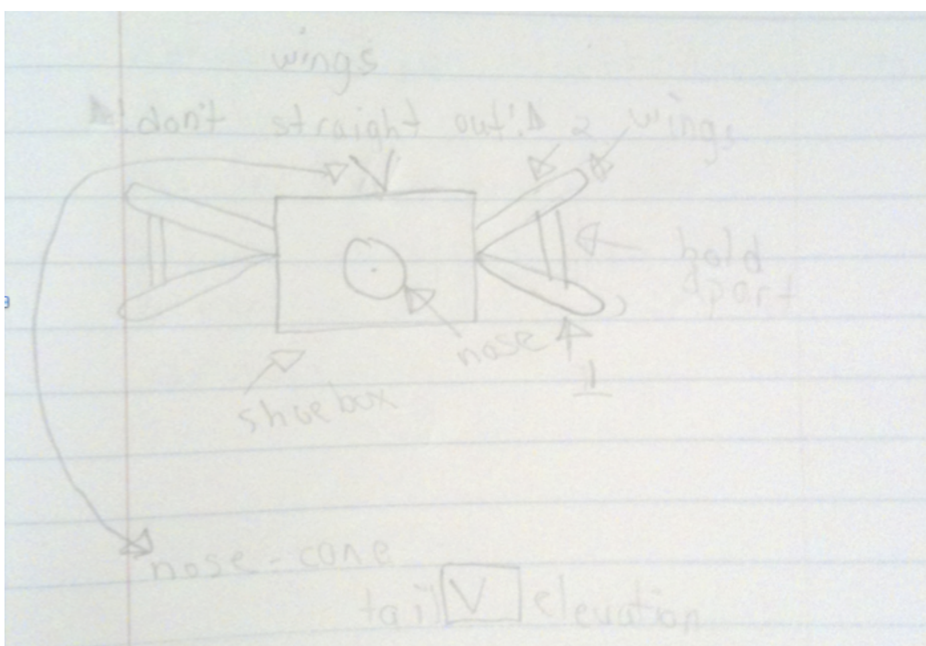

Figure 2. Student Drawing of Glider Design

7th grade male #1* - ***"glider went about 10 feet before hitting the ground. Launched from arms fully extended over head. Nose cone crushed."***

8th grade female #1* – ***"we cut slants in the wings then we folded one side down and one side up then we colored all of the box then we are going to test it out"***

8th grade female #2* - ***"poked holes in the top then put pipe cleaners through them; put sequence in each black dot; put hair on our box; taped the bottom of the box to the top so it wouldn't fly off"***

8th grade female #3 – **"decided we needed hot glue; bottom part of triangle support is approximately 6 inches and the lengths of topsides of triangle supports are approximately 5 inches."**

8th grade female #4 – ***"decided to reinforce the wings with second layer of cut out cake pan; decided to have smaller wings (cake pan wings) on top of shoebox and larger cardboard wings on bottom with straws supporting the wings in between."***

8th grade female #5 – ***"ditched nose cone idea; turned wings into shuttle wings; added top aerodynamic part; Test flight 1 – a little wobbly; Test flight 2 – smooth and straight; spray painted it chrome"***

8th grade male #1* - ***"we couldn't decide on the shoebox; first, we discussed the shoebox we were going to use, we each came up with different ideas faster; someone wanted a small shoebox, another wanted was a really big shoebox, and I wanted was a medium size; we started giving ideas; we didn't want a to heavy shoebox so we picked a small yellow shoebox."***

8th grade male #2* - ***"Body – the body parts: 1. The tail is a little longer because throwing structure is heavier – this allows for better stability; a. the horizontal and***

vertical stability keeps it from turning and going up and down; 2. Nose – we put willow on the nose because the twigs are strong enough that they won't break; they were steady to hold weight and move the weight to make it balance"

8th grade male #3 – ***"we worked on the wing of the plane made out of popsicle sticks and glue and we started on the cone building it so it is protected."***

8th grade male #4 – ***"taped the wings; we know we have to make the back more heavy so it flys straight; now we put two tail fins on the left and right side to make the wind go over the top"***

8th grade male #5 – ***"I added a nose to the front and it worked and added a tail in my box – it ripped in two; I had to start all over but I found a litter bag so I tried to use that over the lid as my wings; there was a hole in the front so the air could though the box and that is where my box got all of the lift from and it went at least 3 yards before it hit the ground"***

8th grade male #6 –see responses from 8th grade male #1 (shared a notebook)

9th grade female #1 - ***"spray painted the wings; we test flew the wings to see how well they would glide".***

Unknown #1 – ***"poked holes in the top then put pipe cleaners through them; taped the bottom of the box to the top so it wouldn't fall off"***

Unknown #2 – ***"I tried it out 4 or 5 times and I think it flys[sic] pretty good. I finely got it to work. I had to start all over 1 or 2 times but I finally got it just right, I think. I'm so proud of myself that I got it done.***

Unknown #3 – ***"I worked on the wings on my aircraft"***

Day 3

6th grade female #1* - no data

6th grade female #2 - ***"Today, I put on the wings and tested how far it can go, which was not very far. So I thought of what might help. I came up with a tail to keep it balanced. Once again, it failed and I'm currently thinking of what to do….I thought if I added a small pair of wings to the tail, it will help it glide instead of crash. So, I sketched out a design and tested it on another shoebox and it works!"***

6th grade female #3 – ***"used popsicle sticks for wings; used sturdy paper and cut out pointed wings; glued the sticks to the wings, put more on the paper, glued, and taped them together on each side. Glued and taped the wings to the box. We tested it to see if it was good because we thought it was a little too heavy and we didn't want to go too far to see if it would break. Tried it a couple of times; the cone broke and the wings got bent. Instead we used a different box to start over. We got Styrofoam and cut wings out a little more bigger and made a curve at the end to get better air dynamics [sic]."***

6th grade female #4 – ***"designed wings"***

6th grade female #5 – ***"on test flight, the glider broke – had to start over. We took 8 feet long Styrofoam wings and rounded them with a Dremel tool"***

6th grade female #6 – ***"cut box to put wings through; tested to make sure; decorated and named it"***

6th grade male #1 – no data

6th grade male #2 – ***"put wings on glider and tested it outside; it need more work because it did flips and then fell to the ground; it didn't go very far"***

6^{th} grade male #4* - ***"I added wings to the bottom and taped them on and added two beams connected to the top to support the wings"***

7^{th} grade female #2*** -** ***"noticed front was too heavy so we put 2 wings on the back"***

7^{th} grade male #1* - ***"glider was repaired with new nose cone and flew about 13 feet before hitting the ground"***

8^{th} grade female #1* – ***"Test and tune: flight 1 – two desk lengths; flight 2 – 3 desk lengths; flight 3 – one desk length; flight 4 – 3 desk lengths"***

8^{th} grade female #2* - ***"wrapped aluminum foil around paper plate wings then taped on the sides of the box"***

8^{th} grade female #3 – **"decided to do 3 triangles for support between wings; the inside triangle will be bigger, the middle triangle will be smaller; the triangles will get bigger as they go out; hot glued top and bottom wings came up with the support plan; tail will have cardboard fins."**

8^{th} grade female #4 – ***"decided we need some hot glue; decided to use 3 triangles for support between the wings; triangles will get bigger as the wings go out"***

8^{th} grade female #5 – no data

8^{th} grade male #1* - ***"________ (student name withheld) emailed me a picture of an idea he wanted to use – a skeleton wing – but said let's see more ideas of what we wanted to use. ____________ (student name withheld) emailed me another picture, it was a good idea he wanted a glider that touches to the top."***

8^{th} grade male #2* - no data

8th grade male #3 – ***"tested plane. It went far but the cone broke so we started to make it bigger with stiraphome[sic] wings."***

8th grade male #4 – no data

8th grade male #5 – ***"I put tag board on it and it didn't go as far as it did without the tag board "***

8th grade male #6 –see responses from 8th grade male #1 (shared a notebook)

9th grade female #1 - ***"brought wings to town and looked for a thin shoebox; we attached the wings with hot glue; attached back fins with popsicle sticks; we attached the wings with hot glue; attached back fins with popsicle sticks"***

Unknown #1 – ***"wrapped foil over wings"***

Unknown #2 – no data

Unknown #3 – ***"I worked on the back part of my propellers; decorated the aircraft putting on the colors and layers of paper"***

Day 4

6th grade female #1* - no data

6th grade female #2 - ***"I've tested my shoebox over 5 times and my shoebox can glide over 3 to 4 meters. I've decided my shoebox won't have a nose because it would add more weight to the shoebox and would cause it to crash…."***

6th grade female #3 – ***"used green spray paint and sprayed the wings. After, we spray painted the box black. When both of them were dry, we taped it around the box; cut 3 pieces of Styrofoam out and layered and glued them together, then smoothed it.***

Spray painted it, tried making it as a cone shape. Cut some stuff from thinner Styrofoam – made it as a tail. The tail broke so we cut more thicker Styrofoam."

6th grade female #4 – ***"made nose"***

6th grade female #5 – ***"We took a new shoebox and the wings and glued them together with spray adhesive. We made a cone out of Styrofoam to balance out the weight. We spray painted the box and traced over our hands."***

6th grade female #6 – ***"cut box to put wings through; tested to make sure; decorated and named it 'the Hands-on Glyder [sic]'"***

6th grade male #1 – ***no data***

6th grade male #2 – ***"fixed up glider and retried flying it from my porch – it went 1 yard then crashed and the nose broke"***

6th grade male #4* - ***"I tried to see if the glider would fly 4 meters but it barely made it. Then tried to see how strong it was to see if it would withstand a crash. The front did but the wings came loose. I took off the wings and changed the front"***

7th grade female #2**** - "tested it – it succeeded!"***

7th grade male #1* - ***"glider went 13-14 feet – hit the ground with no damage cause to plane"***

8th grade female #1* - no data

8th grade female #2* - ***"taped the second wing"***

8th grade female #3 – no data

8th grade female #4 – no data

8th grade female #5 – no data

8th grade male #1* - ***"Talked with ________ (student name withheld) to see if we could make the wings solid and bigger."***

8th grade male #2* - no data

8th grade male #3 – ***"made cone again out of stirophome[sic]; shaped it; painted cone and wings' painted shoebox black; made tail; tested it – broke tail; made back weights; tested – goes good when you tip it up and gently give it a push; painted hands on it"***

8th grade male #4 – no data

8th grade male #5 - no data

8th grade male #6 –see responses from 8th grade male #1 (shared a notebook)

9th grade female #1 - ***""we test flew and wings popped off; used black tape and added more weight and color; hot glued wings; test flew and wings busted off; decided to use thicker sections of hot glue for a better hold"***

Unknown #1 – ***"put in second wing"***

Unknown #2 – no data

Unknown #3 – no data

Day 5

6th grade female #1* - no data

6th grade female #2 – no data

6th grade female #3 – no data

6th grade female #4 – no data

6th grade female #5 – no data

6th grade female #6 – ***"tested it to make sure the paper didn't way[sic] it down'"***

6th grade male #1 – no data

6th grade male #2 – no data

6th grade male #4* - ***"I put on a new wing that was just on big 2 foot long strip of cardboard; to make the wing stronger, I added 2 strips of cardboard to support them; I tested its flight. I figured out that it was unbalanced so I added another 2 foot long strip in the back and taped it to the back; I tested it again and it went way farther than it did but the 2 strips that support the wing weakened so I added 2 square pieces of cardboard to support then it worked and it flew a little bit farther "***

7th grade female #2***** **-** no data

7th grade male #1* - no data

8th grade female #1* - no data

8th grade female #2* - no data

8th grade female #3 – no data

8th grade female #4 – no data

8th grade female #5 – no data

8th grade male #1* **-** ***"it is now complete and we are playing the waiting game"***

8th grade male #2* - no data

8th grade male #3 – no data

8th grade male #4 – no data

8th grade male #5 - no data

8th grade male #6 –see responses from 8th grade male #1 (shared a notebook)

9th grade female #1 – no data

Unknown #1 – no data

Unknown #2 – no data

Unknown #3 – no data

Interviews

Twenty-two students were interviewed. Students were interviewed to obtain the students' descriptions about their Digital Learning Network experience and their attitudes towards STEM careers. Responses from the interviews can be found in Appendix G.

Table 3: Interviewee Demographics

Grade Level	Females	Males	Total
6	1	5	6
7	3	3	6
8	2	3	5
9	2	3	5

Interview Question 1

Did you like learning through NASA's Digital Learning Network? Would you prefer learning with a teacher in the room or with the DLN? Why or Why not?

The consensus among the students interviewed is they liked learning with the DLN. It was a different way of learning but, essentially, it did not matter to the students how they learned – either with the DLN or with a teacher in the classroom; however, the students would have preferred to have more opportunities to ask the DLN Education Specialist questions as the questions came up in their design process.

Interview Question 2

What part of the "Can A Shoebox Fly? Challenge" did you like?

The consensus of the students interviewed was they enjoyed learning through inquiry. That is, the students were given an opportunity to apply their prior knowledge about flight and generate new ideas and possibilities, and to design a product that would satisfy the criteria and constraints of NASA's "Can A Shoebox Fly? Challenge."

Interview Question 3

What part of the "Can A Shoebox Fly? Challenge" did you not like?

The consensus of question 3 from the interviewed students us they liked the challenge. Most students expressed frustration about documenting their design changes, results, etc. in their notebooks. They also expressed frustration with the engineering challenges of designing a shoebox to glide. The frustration became minimal when success was achieved.

Interview Question 4

What was the hardest part of "Can A Shoebox Fly? Challenge?"

For question 4, the consensus among the students interviewed determined the hardest part dealt with some aspect of the engineering design process. The students had to apply their understanding of flight to construct a shoebox that would glide. They also experienced the iterative cycle of the engineering design process where the shoebox design changes as improvements are made.

Interview Question 5

Would you want to do the "Can A Shoebox Fly? Challenge" again? Why or Why not?

Only one student expressed that he would not want to do "Can A Shoebox Fly? Challenge" again. The consensus of the rest of the students interviewed would agree to the challenge again. Their responses were various but most stated some change to their design of their gliders. The evidence of continued learning is present.

Interview Question 6

What career field do you think you want to pursue after high school or college?

Out of the 22 students interviewed, eleven (50%) students state they would like to pursue a STEM career and six (27.3%) students stated they would pursue careers where a science and engineering background would be beneficial in their career choices (mechanic, pilot, and rancher).

Summary of the Chapter

The quantitative data are representative of the data gathered from the student attitudes survey from 55 students. The qualitative findings are representative of the data gathered from the twenty-six student notebooks and twenty-two student interviews. Both the quantitative and qualitative findings presented in this chapter are discussed in Chapter V.

CHAPTER V

CONCLUSIONS

This final chapter represents answers to the research questions on the findings in the previous chapter. The chapter concludes with the limitations of the study as well as recommendations for future research.

Conclusions & Discussions

The purpose of this research was to determine whether NASA's Digital Learning Network's "Can A Shoebox Fly? Challenge" was a viable delivery method to increase student attitudes towards STEM – specifically, science. Overall, the data indicates the "Can A Shoebox Fly? Challenge" delivered through the DLN, is a viable method to increase student attitudes towards science. Evidence was gathered from pre- and post science attitudes surveys as well as from student notebooks and interviews with the students.

Research Questions

> Research Question 1: *To what extent will NASA's Digital Learning Network "Can A Shoebox Fly? Challenge" promotes scientific attitudes in the secondary science curriculum?*

The quantitative data from 55 students in grade 6-9, using a parallel pre- and post science attitudes survey. Each survey allowed for the questions to be grouped into three Factors. Factor 1 is Interest in science classes and activities in science class. Factor 2 is Confidence in ability to do science. And Factor 3 is Interest in science-related activities outside of school. The data also measured the overall attitudes towards science in general. Factors 1, 2, and the general science test all indicate a positive change in science attitudes after completing NASA's Digital Learning Network's "Can A Shoebox Fly? Challenge." Factor 3 indicated a negative change after completing the challenge. The literature indicated that attitude toward science is important because it can enhance cognitive development and increase learning thus an increase in scientific literacy.

Qualitative data was also obtained to determine the extent of the "Can A Shoebox Fly? Challenge" on science attitudes. Twenty-two interviews were conducted to determine the extent of their learning and science attitudes via the DLN. Responses to the interview questions showed that the students enjoyed learning with the DLN despite some frustration with the engineering design process.

The student composition notebooks also contained evidence of learning of the engineering design process. Based on the documentation, the researcher was able to identify the ways the students were constructing a schema of learning.

With the exception of Factor 3, the findings show that the students' attitudes towards science increased after participating in the "Can A Shoebox Fly? Challenge." The evidence obtained indicated the students enjoyed learning about flight and the engineering design process using an inquiry-based approach where the teacher is the facilitator and allows the students to build their own knowledge and construct their own schema. The DLN allowed the students to present their findings to NASA and provided them ownership to their learning. The research believes this fact is the reason why there was a positive change in science attitudes among Factors 1, 2, and overall general science.

The findings from Factor 3, interest in science-related activities outside of school, was not expected; however, after reflecting on the data, the researcher believes the decline in science attitudes is due to the lack of support and motivation for the students. The researcher feels that if the students had been able to ask questions of an "expert" during the design process of their glider, the survey data may not have show a decline in Factor 3. Thus, a recommendation to NASA's Digital Learning Network curricula would be to provide opportunities for the students to ask an expert about a particular design problem. A blog format would work well with the "Can A Shoebox Fly? Challenge." It would not take away instruction time from the teacher or students. The students could blog from home.

Research Question 2: *Is there a gender difference in science attitudes with regards to "Can A Shoebox Fly? Challenge?"*

The quantitative data gathered from the science attitudes surveys suggest no appreciable difference in science attitudes among males and females. Both genders showed a positive change for Factors 1, 2, and general interest in science. Conversely, the data for Factor 3 showed a negative change in male and female science attitudes towards interest in science-related activities outside of school. The literature indicates conflicting studies based on gender, science attitudes, and achievement in science.

The qualitative data obtained from the students' notebooks and interviews also indicated no significant difference in science attitudes and learning among males and females; however, based on the researcher's observations during the second DLN connection, some of the females seemed to be more concerned about the aesthetics of their glider rather than the performance of the glider.

Research Question 3: *How effective is NASA's Digital Learning Network with regards to student interest in STEM careers?*

Only qualitative data was gathered to try to answer this research question. Interviews were conducted with twenty-two students. Fifty percent of the students interviewed stated they would want to pursue a STEM career and 27.3% stated they would explore careers where a background in STEM would be beneficial. Four students emphatically stated they were swayed towards pursuing a STEM career due to participating in the "Can A Shoebox Fly? Challenge." Two students indicated their career choices have changed as well. One of these students is interested in becoming a pilot and the other wants to become a mechanic.

The literature points out that there is a complex relationship among attitudes in science, achievement in science, and career choices. Educators need to provide more real-world experiences for students, which are meaningful, interesting, and relevant, to increase the number of students pursing STEM careers.

Research Question 4: *Does a need exist to modify NASA's Digital Learning Network "Can a Shoebox Fly? Challenge?"*

The feedback the researcher received from the students and from the evidence gathered from the composition notebooks, indicated frustration from the students. The students frustration stemmed from not having a teacher or facilitator who had content knowledge of aeronautics and whom could have provided advice to the students during the design process of the gliders.

Recommendations

The majority of the students enjoyed the “Can A Shoebox Fly? Challenge.” The students were given a challenge to transform an ordinary shoebox into a glider. They researched, designed, built, tested, and repeated the engineering design process as many times as the students deemed appropriate and until they were satisfied with the performance of their glider.

The DLN provided a delivery method that allowed two-way communication between students in a small town in South Dakota with the DLN Education Specialist at NASA Ames Research Center in Sunnyvale, California. The students appeared pleased that NASA would be interested in the gliders they made.

The students were asked to document the changes made to their gliders throughout this process. Most of the notebooks were not well developed. The researcher believes this is due to the lack of experience of the students in documenting their research. One recommendation would be to work with the teacher and subjects beforehand on how to make good qualitative and quantitative observations and how to document appropriately – i.e. What details are and are not significant. Also, some of the students worked in groups and returned a group notebook. The researcher would recommend that each student submit his or her own notebook. These notebooks could then be compared to the other students in that particular group.

Another recommendation for future research on NASA’s Digital Learning Network and/or “Can A Shoebox Fly? Challenge” would be to expose the students to the videoconferencing equipment and etiquette several times before making the actual connection. Some of the students were distracted but the technology during the first connection. For example, the students asked questions about how the green-screen worked. The researcher also explained about the placement of the microphones yet some students, who were sitting near them, would whisper or tap on the table. The microphones would pick up this audio and it became somewhat of a distraction to the DLN Education Specialist.

Summary of the Chapter

The chapter summarizes the findings, discussion, limitations, and recommendations of this study. A review of the literature indicated that little research has been done with NASA’s Digital Learning Network. Further research about the DLN and the impact on student attitudes towards science and STEM career choices needs to be conducted.

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APPENDIXES

APPENDIX A

PERMISSION FROM THE PRINCIPAL OF

KADOKA AREA SCHOOLS

Date: Sat, 3 Apr 2010 13:50:28 -0500
To: ODIN <lisa.r.brown@nasa.gov>
Subject: RE: NASA's digital learning network

Ms. Brown,

Yes, I gave the permission as the Principal to come to Kadoka and conduct your program. I watched some of it and thought it was very good and helpful education for the students. We appreciate the time you spend in coming here and doing this for the students. I hope this suffices as your written permission. Again, thank you.

Tim Hagedorn, Principal
Kadoka Area Schools

From: Brown, Lisa R. (JSC-AD4)[PENN STATE UNIVERSITY] [lisa.r.brown@nasa.gov]
Sent: Friday, April 02, 2010 10:08 AM
To: Hagedorn, Tim S
Subject: NASA's digital learning network

Mr. Hagedorn,
Thank you for allowing me to come to Kadoka and conduct my research. I know that you gave me verbal permission but, to cover my bases, I would like to have "written" permission as well. A response from you to this email should suffice.

To summarize the study, I have attached my methodology document that I was required to submit to Oklahoma State University's Institutional Review Board (IRB). The IRB has to approve of the research to make sure it is valid and will not harm human subjects.

Please feel free to call me at 814-380-0781 if you have any questions. I am looking forward to working with the students and staff in May.
Again, many thanks.
Lisa
Lisa Brown

APPENDIX B

IRB APPROVAL FORM AND PARENT PERMISSION FORM

Oklahoma State University Institutional Review Board

Date:	Monday, April 19, 2010
IRB Application No	ED1049
Proposal Title:	South Dakota Secondary Student Science Attitudes and the Implementation of NASA's Digital Learning Network "Can a Shoebox Fly? Challenge" Module
Reviewed and Processed as:	Expedited

Status Recommended by Reviewer(s): Approved Protocol Expires: 4/18/2011

Principal Investigator(s):

Lisa Ogle Brown	Steven Marks
1102 Mallory Court	309 Cordell North
College Station, TX 77845	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

X The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Shelia Kennison, Chair
Institutional Review Board

Letter to Parent

Dear Parent or Guardian,

Your son/daughter is invited to participate in a science education research project designed to study the attitudes of students in grades 6-9 toward science at Kadoka Middle School and Kadoka High School using NASA's Digital Learning Network "Can a Shoebox Fly?"

If you chose to allow your son or daughter to participate, they will be asked to complete a survey during their science class. The survey should take approximately 15 minutes for your child to complete. The survey contains questions that address your child's attitude toward science (e.g. how they feel about science; if they are interested in science).

While your child is required to participate in the Shoebox Challenge as part of their regular schoolwork, please be assured that survey responses will in no way impact your child's grade in science. In fact, as a way to secure anonymity, your child will not be asked to write their names on the survey. Additionally, the researcher, Lisa Brown, who is a doctoral candidate at Oklahoma State University, will only examine completed surveys. Your child's science teacher will not have access to the completed surveys.

Thank you for your willingness to consider having your child participate in this research.

Sincerely,

Lisa Brown
If you have any additional questions regarding this project, please contact Lisa Brown at 281-468-7674 or Dr. Steve Marks at 405-744-8125.

PARENT PERMISSION FORM

OKLAHOMA STATE UNIVERSITY

PROJECT TITLE: The Implementation of NASA's Digital Learning Network in a South Dakota secondary school and student science attitudes

INVESTIGATOR: Lisa Brown - doctoral candidate at Oklahoma State University

PURPOSE:
This study will examine the effects of NASA's Digital Learning Network "Can a Shoebox Fly? Challenge" and students' attitudes toward science. This study will also gather information regarding how participating in the Shoebox Challenge may have influenced student career choices.

PROCEDURES:
All students are required to complete the Shoebox challenge as part of their regular schoolwork but your child is not required to participate in this study. If you agree to allow your child to take part in this study, your child will be asked to fill out an initial science attitudes survey during his/her science class. Your child will be asked to rate how much he or she agrees with statements about science. Your child will then participate in a videoconferencing event with NASA on the forces of flight and about the Shoebox Challenge. Your child will be asked to design a glider using a shoebox and test his or her shoebox glider. After the shoebox engineering phase, your child will have an opportunity to use videoconferencing to report his or her results back to NASA personnel. Another survey, similar to the survey given at the beginning, will be given to your child afterward during his/her regular science class. Some students will be asked to participate in a face-to-face interview about their experience in the Shoebox Challenge and if it impacted their career choices. The general topics of the questions will be related to your child's views of the Shoebox Challenge, if it has influenced his/her choices of possible careers. The interviews will take place in the conference room at the school during the normal school day. The interviews will <u>not</u> be recorded so that identifiable information cannot be obtained.

Your child's participation in this project is **completely voluntary**. In addition to your permission, your child will also be asked if he or she would like to take part in this project. Only those children who have parental permission and who want to participate will do so, and any child may stop taking part at any time. You are free to withdraw your permission for your child's participation at any time and for any reason without penalty. These decisions will have no affect on your future relationship with the school or your child's status or grades there. I understand that I may call Lisa Brown at 281-468-7674 if I have questions or concerns about the consent form.

RISKS OF PARTICIPATION:

The risks to you and your child are minimal. The information that is obtained during this research project will be kept strictly confidential and will not become a part of your child's school record. Any sharing or publication of the research results will not identify any of the participants by name.

BENEFITS OF PARTICIPATION:

There are no direct benefits for those students choosing to participate is this study, however, their participation might improve the quality of NASA's Digital Learning Network curriculum/modules in future days.

CONFIDENTIALITY:

All information about you and your child will be kept confidential and will not be released. Questionnaires will be identified by subject number only, rather than names on them. All information will be kept in a secure place that is open only to the researcher. This information will be saved as long as it is scientifically useful; typically, such information is kept for five years after publication of the results. Results from this study may be presented at professional meetings or in publications. You and your child will not be identified individually; I will be looking at the group as a whole. It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and wellbeing of people who participate in research.

COMPENSATION:

Your child will receive a certificate for research participation.

CONTACTS:

I understand that I may contact the researchers at the following address and phone number, should I desire to discuss my or my child's participation in the study and/or request information about the results of the study: Lisa Brown, M.Ed., 1102 Mallory Court, College Station, TX; 281-468-7674. I may also contact Dr. Shelia Kennison, IRB Chair, 219 Cordell North, Oklahoma State University, (405) 744-3377 or irb@okstate.edu with any questions concerning participant's rights.

PARTICIPANT RIGHTS:

I understand that my child's participation is voluntary; that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time, without penalty.

CONSENT DOCUMENTATION:
Please place your initials on the line next to the option you have chosen.

_____ I have elected **to** give my permission for my child ___________________________________ (name of child) to participate in the research project described above for ***both the survey and interview processes.***

_____ I have elected **to** give my permission for my child ___________________________________ (name of child) to participate in the research project described above for the ***survey process only***.

_____ I have elected **not** to give my permission for my child ________________________________ (name of child) to participate in the research project described above. Your child's participation in this project is completely voluntary. These decisions will have no affect on your future relationship with the school or your child's status or grades there.

- I have been fully informed about the procedures listed here. I am aware of what my child and I will be asked to do and of the benefits of participation. I also understand the following statements:
- I affirm that I am 18 years of age or older.

I have read and fully understand this consent form. I sign it freely and voluntarily. A copy of this form will be given to me. I hereby give permission for my child and my participation in this study.

____ _________________________
Signature of Parent/Legal Guardian Date

____ _________________________
Signature Witness Date

I certify that I have personally explained this document before requesting that the participant sign it.

________________________________ _____________ _______________________
Signature of Researcher Date

ASSENT FORM
OKLAHOMA STATE UNIVERSITY

Dear Student,

Thank you for your willingness to participate in this research project. The purpose of this project is to study the attitudes of middle school and high school students towards science. It is hoped that the information gathered in this study will be used to improve the quality of NASA's Digital Learning Network student learning modules.

Please understand that you do not have to participate in this survey or interview. You do not have to answer any questions that you do not want to. You may stop at any time and go back to your regular class work.

If you choose to participate, you will be asked to complete a survey. The survey should take approximately 15 minutes for you to complete. After completing the Shoebox Challenge, you will be asked to complete another survey. You may also be asked to participate in a interview where the researcher will ask you questions regarding your experience in the Shoebox Challenge. The questions are not meant to be embarrassing and your responses will not be recorded.

Your name will not be on the forms you fill out, and you will choose a number that will be put on your answer sheet so no one will know whose answers they are. If you have any questions about the form or what we are doing, please ask us. Thank you for your help.

Sincerely,

Lisa Brown
Graduate Student Oklahoma State University

Steve Marks, Ed.D.
Professor Oklahoma State University

I have read this form and agree to help with your project.

____
(your name**)**

____

(your signature)

____

(date)

APPENDIX C

ATTITUDE SURVEY INSTRUCTIONS

This survey is designed to gather information about your attitude toward science. Before you begin the survey, circle the corresponding answer to your sex and write in your grade level on the survey. Write a 4-digit number you can remember in the "Special Code" boxes, and check the corresponding box to your answers. **Do not put your name on the answer sheet. The researchers need your student number only to keep track of the responses. They will not be able to find out your name from your student number.**

Some of the statements in the survey refer to "science." You should think about any science classes you have taken when you respond to those statements. Some statements refer to "biology." You should think about any biology classes you have taken or any parts of science classes in which you learned about living things. Some statements refer to "physical science." You should think about classes such as chemistry, physics, geology, or earth science, or any parts of science classes in which you learned about chemicals, the earth, machines, or similar topics. If you have not yet had a class in biology or in any physical science, respond to the statements on the basis of what you know or have heard about those classes.

Please read the statements and decide how much you agree with each. Using the following list, check the box that matches how you feel about each statement.

Strongly agree
Agree
Neither agree nor disagree
Disagree
Strongly disagree.

Example: *I enjoy reading scary stories.*

If you really don't like scary stories, you would probably "strongly disagree" with this statement, and would check the box labeled "Strongly Disagree" on the survey. If you like scary stories somewhat, you would probably "agree" with this statement, and would check labeled "Agree" on the answer sheet.

APPENDIX D

SURVEY FORMS

Special Code

Please circle

Male Female

Grade level ___________

Form A

Please read the statements and decide how much you agree with each. Check the box that corresponds with your answer.

		Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly Disagree
1	I wonder about stars and constellations.					
2	I do not want to take any more science classes than I have to take.					
3	I enjoy the challenge of science classes.					
4	I do not enjoy identifying shells.					
5	I have a talent for biology					
6	I would not recommend science classes to anyone					
7	I am confident about answering questions in science classes.					
8	I do not enjoy taking things apart to see how they work.					
9	Studying physical science is boring					
10	I like to share what I've learned in science class with my friends or family					
11	I am interested in learning more about topics in biology.					
12	I doubt I will ever grasp biology					
13	I am not confident about my ability to understand science					
14	I do not think about the things I learn in science class outside of school					
15	I enjoy participating in hands-on activities in physical science classes.					
16	I enjoy reading books about science.					
17	I have a talent for physical science					
18	I do not enjoy doing labs in biology classes					

19	Physical science makes sense to me.					
20	Science classes are too difficult for me.					
21	I am interested in learning more about topics in physical science.					
22	Biology makes no sense to me.					
23	I enjoy taking care of animals					
24	I do not enjoy watching TV shows that deal with science.					
25	I like learning about rocks and minerals.					
26	Studying biology is boring					
27	Science classes are interesting					
28	I doubt I will ever grasp physical science.					
29	I do not like to read about different kinds of animals					
30	I am fascinated by what I learn in science classes					
31	Science is fun.					
32	I do not like science and it bothers me to have to study it.					
33	During science class, I usually am interested					
34	I would like to learn more about science.					
35	If I knew I would never go to science class again, I would feel sad.					
36	Science is interesting to me and I enjoy it.					
37	Science makes me feel uncomfortable, restless, irritable, and impatient					
38	Science is fascinating and fun.					

Thank you for completing this survey.

Special Code

Please circle
Male Female
Grade level __________

Form B

Please read the statements and decide how much you agree with each. Check the box that corresponds with your answer.

		Strongly agree	**Agree**	**Neither agree or disagree**	**Disagree**	**Strongly Disagree**
1	I do not want to study any more science.					
2	I often ask my family how mechanical things work.					
3	I do not enjoy watching and learning about birds.					
4	I like to repair things such as bicycles or cars.					
5	Learning things in biology is easy for me.					
6	Paying attention in physical science classes is hard for me.					
7	I would or do belong to a science-related club.					
8	I am not able to easily understand topics in physical science.					
9	I like going to biology classes because I learn interesting things.					
10	I would not try to learn about science on my own.					
11	I have the ability to be successful in science classes.					
12	Biology seems to be "over my head."					
13	I do not enjoy doing labs in physical science classes					
14	Although sometimes science is difficult, I enjoy trying to understand it.					
15	I am afraid to ask questions in science classes.					
16	I feel overwhelmed in science class.					
17	Learning things in physical science is easy for me					
18	I am able to easily understand topics in biology.					
19	I enjoy reading about science in the newspaper or magazines.					
20	I do not enjoy talking about science with my friends.					

21	Paying attention in biology classes is easy for me.					
22	I enjoy science classes					
23	I would not like to learn more about the weather					
24	I do not enjoy reading about animals that live in the ocean.					
25	I like going to physical science classes because I learn interesting things.					
26	Physical science seems to be "over my head."					
27	Science classes should be required only for students who plan on being scientists.					
28	I have or would like to have a job dealing with animals.					
29	Things that I learn in science classes interest me.					
30	I do not enjoy participating in hands-on activities in biology classes.					
31	The feeling that I have towards science is a good feeling.					
32	When I hear the word science, I have a feeling of dislike					
33	Science is a topic which I enjoy studying					
34	I feel at ease with science and I like it very much					
35	I feel a definite positive reaction to science					
36	Science is boring.					

Thank you for completing this survey.

APPENDIX E

CORRESPONDENCE FROM

INGRID NOVODVORSKY

FROM: Ingrid Novodvorsky <novod@email.arizona.edu>

Date: Tue, 23 Feb 2010 ll:12:17 - 0600

TO: ODIN ,lisa.r.brown@nasa.gov>

Subject: Attitude towards science instrument

Lisa

What an interesting study area . . .is that an official major at OK State, or something you've put together?

You are welcome to use the instrument I developed for my dissertation, please let me know if you need a Word version of the document. I'd be very interested in reading the results of your research.

Do you have any contact with Caroline Beller in the College of Education thee? I know her from the Physics Teacher Education Coalition.

Ingrid

Dr. Novodvorsky

I am a doctoral student at Oklahoma State University studying Aviation and Space Science Education. During the literature review for my dissertation, I came across your 1993 research on student attitude science instruments. I would like permission to use the instrument developed in that paper. I am researching the science attitudes of students (grades 6-9) after participating in a NSASA Digital Learning Network module.
Thank you in advance for your consideration

Regards,
Lisa Brown

APPENDIX F

WING-ON-A-STRING ACTIVITY

Lesson 1: Pathfinder on a String
Grades 5-8

Objective
- To demonstrate how lift is created as air passes around an airfoil or wing.

Science Standards
Science as Inquiry
Physical science-position and motion of objects
Unifying concepts and processes- Evidence, models, and explanations

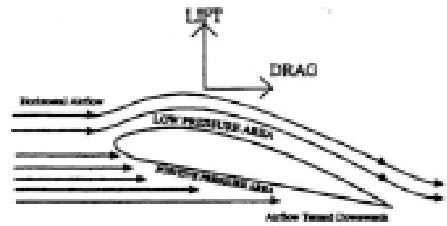
Science Process Skills
Observing
Communication
Making models

Mathematics Standards
Reasoning
Connections
Communication

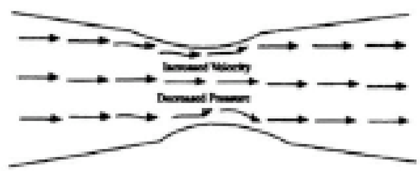
Management
This activity uses a combination of an activity done in pairs, and constructing a model of an airfoil which is done individually. Allow one to two class periods, 40-45 minutes long, to complete both sections. In part one, students reenact the movement of air around and airfoil and how this movement affects air pressure. Students then discuss their observations, draw a diagram of their experiment, and their discoveries in writing. In part two, students will construct an airfoil, which resembles the NASA Pathfinder, and fly it.

Background Information
The NASA Pathfinder is a classic design called a flying wing. This design and the wing span of 100 feet allows the aircraft to fly at very high altitudes and very low velocities and maximizes the amount of energy used to remain in flight. Pathfinder is a solar powered plane and is part of the growing ERAST fleet of aircraft designed to assist NASA in its research and development technologies focusing on environmental issues. ERAST stands for Environmental Research Aircraft and Sensor Technology.

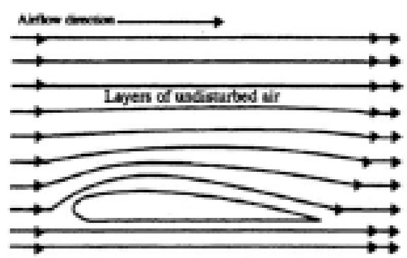
Basic principles of Aeronautics



Difference in pressure between upper and lower surfaces produce lift



Flow of air through a Venturi tube



Curvature of airfoil and layer of undisturbed air act as the constriction in a Venturi tube

Bernoulli's Principle

To understand how lift is produce, we must examine a phenomenon discovered in the late 1600's by the scientist Bernoulli and later called Bernoulli's Principle: *The pressure of a fluid (liquid or gas) decreases at points where the speed of the fluid increases.* In other words, Bernoulli found that within the same fluid, in this case air, high speed flow is associated with low pressure, and low speed with high pressure. This principle was first used to explain changes in the pressure of fluid flowing with a pipe whose cross sectional area varied. In the wide section of the gradually narrowing pipe, the fluid moves at low speed, producing high pressure. As the pipe narrows it must contain the same amount of fluid. In this narrow section, the fluid moves at high speed, producing low presure.

An important application of this phenomenon is made in giving lift to the wing of an airplane, an airfoil. The airfoil is designed to *increase the velocity of the airflow above its surface,* thereby *decreasing pressure above the airfoil.* Simultaneously, the impact of the air on the lower surface of the airfoil increases the pressure below. This combination of pressure decrease above and increase below produces lift.

Lift

Probably you have held your flattened hand out of the window of a moving automobile. As you inclined you hand to the wind, the force of air pushed against it forcing your hand to rise. The airfoil (in this case, your hand) was deflecting the wind which, in turn, created an equal and opposite dynamic pressure on the lower surface of the airfoil, forcing it up and back. The upward component of this force is lift. Lift is also defined as a force generated by turning a flow of air by the wing shape. It is in this respect, an application of Newton's Second Law, (F=ma) where F= the force, m= the mass and a=acceleration.

Description

Students will move together in pairs around a table or a set of desks in order to simulate the movement of air around an airfoil. After each pair of students have completed the simulation a class discussion will lead to the concept that the air moving underneath an airfoil has higher air pressure than the air moving over the top of the airfoil, thus creating lift. This is called the Bernoulli Principle, named after Jakob Bernoulli (1654-1705) who was a Swiss physicist and mathematician. After describing this property in writing the students then will construct a paper airfoil with a length of monofilament running through it in order to demonstrate the Bernoulli Principle.

Pathfinder on a String
Part 1

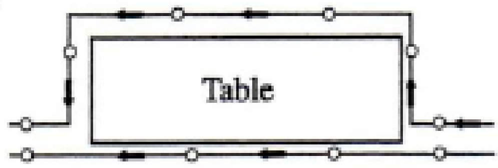
Materials and Tools

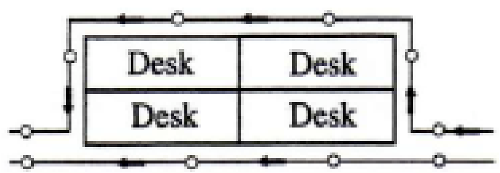
- Tables, or sets of desks arranged into rectangles
- One copy of the student worksheet for each student
- Optional, masking tape
- Optional, overhead copy of the student worksheet

Procedures

Simulation

1. Prior to the start of class arrange your tables or desks so the face the same direction and there is enough room between them for the students to walk around them.
2. If you wish you might mark the path the students will follow with masking tape taped to the floor.
3. Students will need to find, or be assigned, a partner.
4. Instruct the students to walk slowly, shoulder to shoulder, towards the table or desks as shown in the diagram below. When they reach the desks one student will be able to continue walking straight, the other student will have to go around the tables. Inform them that it is very important that they get to the table, and meet at the opposite side of the table, at the same time. Also, the person walking straight should maintain the same pace they used when they were approaching the table, that is, they should not slow down or speed up. The student who has to walk around the tables may need to adjust their speed in order to meet their partner on the opposite side.





5. Have the students do a practice run of this and clear up any confusion.
6. Once any questions have been answered tell the students that this time, in addition to walking around the desks or table, they will have to press down on the top of the desks or table as they move by it. They should pay close attention to how much pressure they can put on the table and continue moving at the appropriate pace.

Bernoulli's Principle

To understand how lift is produce, we must examine a phenomenon discovered in the late 1600's by the scientist Bernoulli and later called Bernoulli's Principle: *The pressure of a fluid (liquid or gas) decreases at points where the speed of the fluid increases.* In other words, Bernoulli found that within the same fluid, in this case air, high speed flow is associated with low pressure, and low speed with high pressure. This principle was first used to explain changes in the pressure of fluid flowing with a pipe whose cross sectional area varied. In the wide section of the gradually narrowing pipe, the fluid moves at low speed, producing high pressure. As the pipe narrows it must contain the same amount of fluid. In this narrow section, the fluid moves at high speed, producing low presure.

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Part 1

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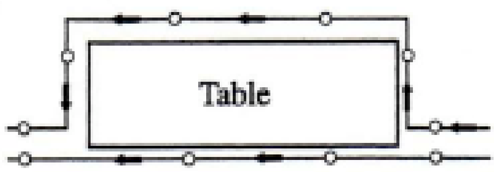
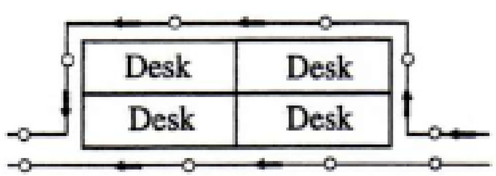
Simulation

1. Prior to the start of class arrange your tables or desks so the face the same direction and there is enough room between them for the students to walk around them.
2. If you wish you might mark the path the students will follow with masking tape taped to the floor.
3. Students will need to find, or be assigned, a partner.
4. Instruct the students to walk slowly, shoulder to shoulder, towards the table or desks as shown in the diagram below. When they reach the desks one student will be able to continue walking straight, the other student will have to go around the tables. Inform them that it is very important that they get to the table, and meet at the opposite side of the table, at the same time. Also, the person walking straight should maintain the same pace they used when they were approaching the table, that is, they should not slow down or speed up. The student who has to walk around the tables may need to adjust their speed in order to meet their partner on the opposite side.





5. Have the students do a practice run of this and clear up any confusion.
6. Once any questions have been answered tell the students that this time, in addition to walking around the desks or table, they will have to press down on the top of the desks or table as they move by it. They should pay close attention to how much pressure they can put on the table and continue moving at the appropriate pace.

Student Worksheet

Name ____________________

Date ____________________

Draw a diagram of the classroom activity. Be sure to label the pathway, which person walked faster, which person walked slower, which person could exert the most pressure, and which person had to exert less pressure.	Draw a cross section of an airfoil. Be sure to label the pathway of the air, label which side of the airfoil the air moves the fastest and the slowest, and which side of the airfoil is being subject to high air pressure and which side is subject to low air pressure.

From your diagram above, and using the information discussed in class, in complete sentences explain how lift is created by an airfoil.

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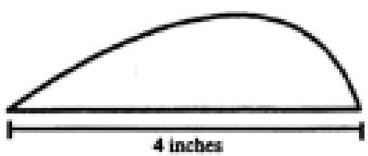
Part 2

Materials and Tools,

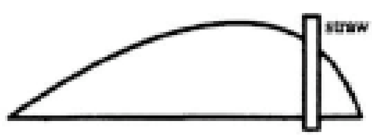
- One yard of 10-lb. test monofilament, or fishing line, per student
- One straw, non-flexible, per student
- Four to six pieces of transparent tape 1"-2" long
- One sheet of 8 1/2" x 11" paper per student
- Scissors

Procedures

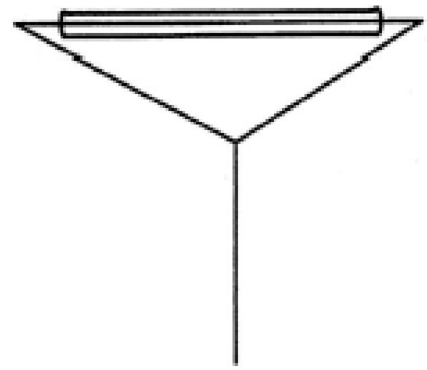
1. Distribute the materials to the students.
2. Students will take the sheet of paper and put a horizontal fold in it about four inches from one of the short edges. The measurement doesn't need to be exact, but it is important that they DO NOT fold the paper precisely in half.
3. Next, they need to align the short edges of the paper and tape them together in two or three places.



4. Have them carefully label the relative air speed and air pressure along the bottom and along the top as a reinforcement of the class activity.
5. Using their pencil they should poke a hole in the bottom of the airfoil.
6. One end of the straw should be inserted into the hole.
7. Looking inside the airfoil from the side, the students should move the straw until it appears to be as close to vertical as possible. They need to mark the spot where the straw meets the top of the airfoil. Take the straw out and poke a hole in the top of the airfoil with a pencil at the mark.
8. Reinsert the straw making sure it extends beyond the edge of the airfoil. The straw needs to be cut so there is about 1/4" extending above the top of the airfoil and below the bottom of the airfoil.



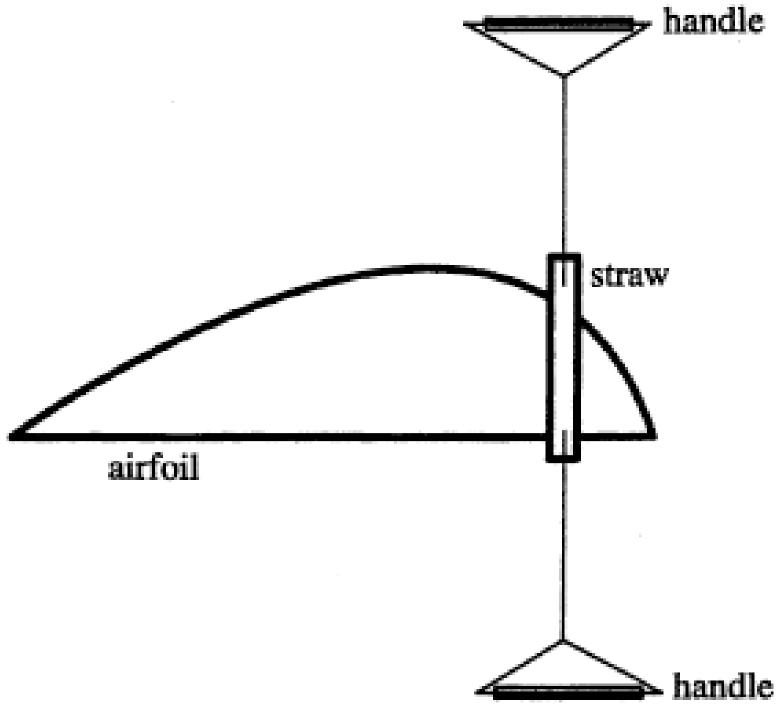
9. Tape the straw in place on the top and the bottom.
10. Cut the remaining straw section in half to serve as handle.
11. Thread the monofilament through the straw section in the airfoil.
12. Place one half of the remaining straw section on the monofilament. Tie a square knot a few inches below the straw section to create a handle.



13. Repeat step 12 on the other end of the monofilament.
14. Holding one handle in each hand, positioning the monofilament so it is vertical and pulled tight, and the air foil is right side up; the students should walk very quickly or jog, maintaining their hand position. As they move the airfoil will "fly".

Assessment

Collect and review student worksheets.


handle
straw
airfoil
handle

Lesson 2: Wing Area and Lift
Grades 5-8

Objective

- To determine if a change in the wing area affects the amount of lift created by the wing.

Science Standards

Science as Inquiry
Physical science-position and motion of objects
Unifying concepts and processes-
Evidence, models, and explanations
Science and Technology-Abilities of technological design

Science Process Skills

Observing
Communication
Making models
Controlling variables
Collecting data

Mathematics Standards

Problem Solving
Reasoning
Connections
Communication
Measurement
Geometry
Statistics

Management

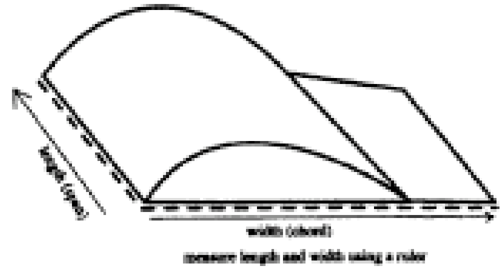
This lesson is divided into two sections. The first section has the students constructing an airfoil to certain specifications, then flying the airfoil and altering the amount of weight it is carrying. In the second section the students will plot and analyze the data collected from the class and draw conclusions about wing area and the amount of lift created. This lesson is most effective when students work in small groups of 3-4 students. Allow two class periods, 40-45 minutes in length to complete both sections.

Background Information

The NASA Pathfinder has a very large wing span and, as a result, a large wing area. The purpose of this is two fold. First, the increased wing area allows for the placement of numerous solar panels on the top of the wings, which serve as the power source for the propellers and various other instruments. Second, the increased wing area generates more lift than what smaller wing area planes generate. This allows the pathfinder to be very fuel-efficient, especially with its light weight construction.

Description

Students will be constructing airfoils similar to those made in activity 1, but which must meet certain specifications such as size of paper and where to tape the trailing edge. Once the airfoil is constructed the surface area, or wing area, will be calculated using the lenght measurement (wing span) and the distance from the leading edge to the trailing edge at the bottom plane of the wing (wing cord).



After the calculations have been done the students will fly the airfoil several times, adding paper clips each time, until the airfoil becomes to heavy to fly. The paperclips will serve as a way to measure the amount of lift created by the airfoil.

Once all groups have reached their maximum flight weights the class will generate a scatter plot comparing the wing area and the amount of weight lifted. Conclusions on this relationship will be made through class discussion and a written analysis of the scatter plot.

Wing Area and Lift

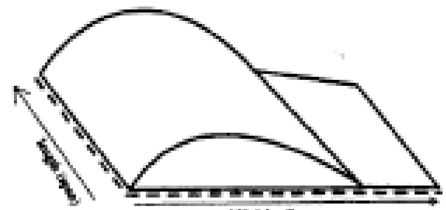
Materials and Tools

- Class set of task cards, enough so each group can have one task card
- One yard of 10-lb. test monofilament, or fishing line, per group
- One straw, non-flexible, per group
- Four to six pieces of transparent tape 1"-2" long
- One 12" piece of string per group
- One ruler per group
- Scissors
- One box of large 2" paperclips per group
- Ten to twenty sheets of 8 1/2" x 11" sheets of blank paper
- Ten to twenty sheets of 8 1/2" x 14" sheets of blank paper
- One copy of the student worksheet per student
- One piece of graph paper per student, or one copy of the included grid per student
- Calculator
- One overhead transparency of the student worksheet, or a large chart made of butcher paper for recording class data

Procedures

Simulation

1. Put the students into pairs or small groups and number the groups. The numbers will be used when recording the class data prior to constructing the scatter plot.
2. Inform the groups that they will be constructing one airfoil per group similar to the one they constructed in the previous lesson, but they must meet certain specifications, which are printed on the task card they will receive. Distribute the task cards and allow the students 10-15 minutes to construct their airfoil. Refer to the directions in the first lesson if necessary.
3. Distribute one copy of the student worksheet to each person.
4. Explain that the students will be conducting an experiment to help determine whether the surface area of a wing, also called the wing area, has an effect on the amount of lift created. The lift will be measured by counting how many paperclips the wing can hold and still fly.
5. The groups will need to calculate the wing area by measuring the width of the wing and the length of the wing, at the bottom plane, and multiplying the measurements. Use a ruler to make these measurements. This information needs to be recorded on the student worksheet.



6. After calculating the wing area have the groups first predict how many paperclips they think it will take before the airfoil cannot fly any longer.
7. Have the groups begin conducting their experiment. After each flight they need to add one paperclip to the trailing edge of the airfoil. When they have reached the point at which their airfoil will no longer fly they need to record the number of paperclips they used.
8. Once all groups have reached the maximum weight lifted by the airfoil have a member from each team record their airfoil surface area and maximum number of paperclips used on the overhead transparency or butcher paper chart.
9. Conduct a class discussion on any observations the students may have made during the activity. You may want to focus on items such as whether the location of the paperclips (centered, off to one side, etc.) had any bearing on the flight of the airfoil, were they surprised by the number of paperclips used, and anything else the students may want to share.
10. Distribute a piece of graph paper to each student. Show them how to set up a set of axis for a scatter plot labeling the vertical axis with the number of paperclips used and the wing area along the horizontal axis.
11. Using the class data from the chart show the students how to plot each point beginning by locating the wing area along the horizontal axis, the number of paperclips used with that wing area along the vertical axis. Then trace an imaginary line up from the bottom and across from the side to find where these two pieces of data meet and mark it with a dot. Continue to do this with each piece of data. Do not connect the dots.

12. Conduct a class discussion using the scatter plot. These questions may be used as a guide:

- Do the dots make any kind of pattern? Looking left to right do the dots go up, go down, or have no pattern? *(Dots should go up)*
- As the surface area increases for each wing what do you notice about the number of paper clips used? *(As the surface area increases the number of paper clips used increases)* Remind the students that the number of paperclips is being used to measure the amount of lift created by the airfoil. More paper clips indicate more lift.
- What conclusion can you make about the surface area of a wing and the amount of lift created? *(The more surface area a wing has the more lift that is created)* Have the students write their conclusions in complete sentences below the scatter plot.

Assessment

Collect and review student worksheets.

Extensions

- Find the mean, median, and mode of the area and weight.
- Use a graphing calculator as another means of presenting the data.
- Use a computer to create a spreadsheet to show the information.
- Make a pictograph that shows the data.

APPENDIX G

INTERVIEW QUESTIONS

Interview Question 1: Did you like learning through NASA's Digital Learning Network? Would you prefer learning with a teacher in the room or with the DLN? Why or Why not?

6th grade male #1 – " Yes, I liked that we could have a 2-way conversation with NASA."

6th grade male #2 – "I liked the DLN a lot. I would want to be taught with the DLN."

6th grade male #3 – "It (the DLN) was pretty good. I liked the DLN and would prefer doing that."

6th grade male #4 – "I liked the DLN and Greg (the DLN Education Specialist). It was more comfortable and something new and different."

6th grade male #5 – "It was good. It doesn't matter if the teacher is there or the DLN."

6th grade female #1 – "I liked the DLN a lot. It doesn't matter to me if it's the DLN or in-person."

7th grade female #1 – "The DLN was fun. I learned a lot from Greg and it is different from regular school".

7th grade female #2 – "Yes, I liked the DLN but it doesn't matter."

7th grade female #3 – "The DLN was awesome. It helped me get to know some more NASA people and they made me feel comfortable. I prefer the teacher to be in-person because you can interact with the teacher."

7th grade male #1 – "I liked the DLN and watching the videos of the wing design. I would prefer the DLN because Greg knew more about planes than the teacher."

7th grade male #2 – "I liked the DLN and learning how to do a wing design. I want someone in person because you can ask many more questions."

7^{th} grade male #3 – "I liked the DLN. Greg was funny and I got to learn about stuff like the green screen. It doesn't matter if it's with the DLN or a teacher."

8^{th} grade female #1 – "The DLN was fun and I liked it. I got to see other shoebox designs. I like in-person because you are able to see demonstrations better."

8^{th} grade male #1 – "I liked the DLN and seeing the videos of the experimental planes. It doesn't matter to me if it was in-person or with the DLN."

8^{th} grade male #2 – "I liked the DLN and the videos and the tips on balancing the glider. I would like to do both. The DLN can tell you what you are doing correct and it can tell you what you are doing wrong and the teacher can help you put it together."

8^{th} grade female #2 – " I liked it and it was fun. It was something new. I would like to do it every once in awhile. In person or with the DLN – it doesn't matter."

8^{th} grade male #3 – "The DLN is a great way to communicate. There is a 2-way interaction and it uses the TV, which is something I like. The DLN is better because he (the DLN Education Specialist) is a long way away and can still come into the classroom."

9^{th} grade female #1 – "The DLN was interesting. I have never done it before. I like it but I think I prefer in person so the teacher can help me when I need it."

9^{th} grade male #1 – "The DLN was alright. I liked the 2-way interaction where you can see the person and talk with him. It doesn't matter to me if the teachers is there or with the DLN."

9^{th} grade female #2 – "The DLN was fun. It was something different that we did. It doesn't matter but it might be better if it was done in person because that person will be on hand to consult with"

9th grade male #2 – " The DLN was pretty cool. It was my first time doing it and it was interesting. The DLN is a lot cooler and you have to pay attention because I thought it was kind of neat that we could do that."

9th grade male #3 – "The DLN was alright. It probably doesn't matter if I learn with a teacher or the DLN."

Interview Question 2: What part of the "Can A Shoebox Fly? Challenge" did you like?

6th grade male #1 – "I liked building and testing it. It didn't work the first time so I changed it by adding weight and it worked. I also liked working with a partner."

6th grade male #2 – "I liked that you can pick out what materials you want to use and working with a partner. It helped you figure things out with a partner."

6th grade male #3 – "I liked putting stuff on the box and figuring out what would work."

6th grade male #4 – "I liked using recyclable materials. It was easier than having to buy stuff. I used my imagination."

6th grade male #5 – "The best part was learning how to put on the wings. I had to slant them for lift and I tested them three times."

6th grade female #1 – "I liked building it and working together with a friend."

7th grade female #1 – "I liked the Shoebox because I got to build it by myself and with my father."

7th grade female #2 – "I kind of liked the Shoebox Challenge. I liked decorating it and figuring out how to make the wings. I got to work with a partner to bounce ideas off each other."

7th grade female #3 – "I liked it, especially building it. I got to work with my sister (a fourth grade student) and I got to know her a little better. We worked together as a team".

7th grade male #1 – "I liked it – the building and testing it. I had a partner. We didn't draw it but we put stuff together. We used a commercial airplane as inspiration. "

7th grade male #2 – "I liked doing different designs and seeing which worked better. I also liked working with a partner."

7th grade male #3 – "I liked it. I liked building it and coming up with a design and putting it together, trying out different materials, and I worked with my brother, who is in 6th grade."

8th grade female #1 – " I liked it. I liked that we could show off our design, testing it, and working with partners."

8th grade male #1 – "It provided a challenge. You had to come up with different ideas for gliders. I liked working with a partner. The glider building was a lot of fun."

8th grade male #2 – "I liked it. I liked the designing and testing it."

8th grade female #2 – " I liked the challenge. It didn't have to look a specific way and we could make it the way we wanted. I had two other partners. We did the ladybug design. I liked collaborating with each other. It was something new and different."

8th grade male #3 – "I exactly loved it. It was a better way to learn. I learned geometry and mass and I had to apply math skills and science. I had to do the activity than on a piece of paper. I had a partner to get to share ideas and mix ideas – two heads are better than one. I bonded with my friend and it was a good way to spend time with a friend."

9th grade female #1 – "I liked it. I decorated my glider with wrapping paper. I made something that can fly. I liked designing it and working with my little sister and cousin."

9th grade male #1 – " Yes. I might have enjoyed it anyway even if it wasn't for a grade. "

9th grade female #2 – "It was fun because I got to be creative. I liked trying out different things and to see how well we actually did flying it and getting basic knowledge of flight. I liked working with a partner since it is easier than doing it by myself. Everyone's ideas put together helped a lot."

9th grade male #2 – "It was pretty cool. I liked trying to figure out how to build it and it's shape and stuff."

9th grade male #3 – "It was alright. I kind of threw it together. I worked with a team of a total of four people."

Interview Question #3: What part of the "Can A Shoebox Fly? Challenge" did you <u>not</u> like?

6th grade male #1 – "Nothing. I liked it"

6th grade male #2 – "Nothing."

6th grade male #3 – "Nothing."

6th grade male #4 – "I liked the whole thing and would do it again."

6th grade male #5 – "Nothing."

6th grade female #1 – "Greg (the DLN Education Specialist) was a little boring."

7th grade female #1 – "Nothing."

7th grade female #2 – "I did like figuring out how to put it together and was frustrated but I worked through it. I also didn't like writing down what we had to do."

7th grade female #3 – "I had to make it for a grade."

7th grade male #1 – "Writing down everything. "

7th grade male #2 – "I was frustrated when the thing didn't work. I wanted to have a good shoebox to try to win the fartherest [sic] distance."

7th grade male #3 – "Having to find a shoebox."

8th grade female #1 – " I was frustrated when the shoebox didn't fly."

8th grade male #1 – "Trying to find materials that would work."

8th grade male #2 – "I didn't like when it didn't work the first time – it crashed."

8th grade female #2 – " The trial and error and trying to find the weight and wings to fly right."

8th grade male #3 – "Nothing. I liked it 100 percent! I liked the hands-on."

9th grade female #1 – "I didn't like figuring out the different wings to make the glider better and more stable."

9th grade male #1 – " Nothing. "

9th grade female #2 – "I didn't like not having enough time to get it done. It was lots of pressure. I put it off a little but worked on it every week. It wasn't difficult and I pretty much liked it all."

9th grade male #2 – "It was a lot of hard work painting it and trying to get the stripe straight."

9th grade male #3 – "Nothing."

Interview Question 4: What was the hardest part of "Can A Shoebox Fly? Challenge?"

6th grade male #1 – "It didn't work the first time I tested it so I changed it, added weight, and it worked."

6th grade male #2 – “I changed some things on the design by changing the nose and back end. I tested my throwing technique. The first time, I threw it really hard and it dove straight down then I threw if softer and it worked better.”

6th grade male #3 – “The wings. I kept the lid and taped it down. I used a cardboard box to cut out the wings. I had two different wings – one small and one big. I decided to go with the big wing because I have seen other planes, real planes, and thought it would help. I used a two-liter pop bottle for the nose because I thought it would fly faster.”

6th grade male #4 – “It wasn’t really hard. I had to test it to see if it would work and I didn’t use a partner because I just wanted to use my own ideas..”

6th grade male #5 – “The hardest part was how heavy the shoebox is. I had to figure out the weight to make it go far.”

6th grade female #1 – “Finding stuff to help it fly. I used thick cardboard for the wings.”

7th grade female #1 – “The hardest part was trying to find a shoebox.”

7th grade female #2 –“ Putting it together so it didn’t fall apart.”

7th grade female #3 – “Trying to get the wings on. I had to have my sister hold it and I taped them.”

7th grade male #1 – “The hardest part was getting a design that would work.“

7th grade male #2 – “Getting it to glide. I had to change the location of the wings on the box.”

7th grade male #3 – “It was hard to develop a design. I made a testing plane and then I developed the real one. I didn’t want to cut up the real shoebox. I ended up putting the wings on top. My whole family got involved. I looked on the internet and saw a bunch of designs and my mom went to YouTube and looked up Shoebox glider movies.”

8th grade female #1 – "It was hard to make sure it would fly."

8th grade male #1 – "The hardest part was making sure that it didn't flip when it flew."

8th grade male #2 – "I had a hard time finding the right tools – cutting knives for twigs and finding tape. I worked with my father and it was the first time working with him."

8th grade female #2 – "It was the trial and error and trying to find the balance with the wings to fly right."

8th grade male #3 – "Determining the weight. If you put too much weight in the front, it does a nose dive and too much in the back, it flips over and too much on the sides, it tilts."

9th grade female #1 – "It was hard figuring out the different ways to make the glider better – more stable."

9th grade male #1 – "Cutting the wings out was the hardest part and getting them on straight. I needed them level."

9th grade female #2 – "It was hard trying to get it to stay in the air and to calculate the weight and balancing it out."

9th grade male #2 – "Painting it was hard."

9th grade male #3 – "The hardest part was coming up with an idea."

Interview Question 5: Would you want to do the "Can A Shoebox Fly? Challenge" again? Why or Why not?

6th grade male #1 – "Probably. I liked working with a partner."

6th grade male #2 – "Yes. I would learn better if all my class work was like this."

6th grade male #3 – "Yes, but I would change my design."

6th grade male #4 – “I liked the whole thing and I would do it again.”

6th grade male #5 – “Yes, but I would change the wings to make them bigger – longer not wider.”

6th grade female #1 – “No. I didn’t like the whole thing.”

7th grade female #1 – “Yes, I would do it again. I liked working with my dad.”

7th grade female #2 –“ Yes.”

7th grade female #3 – “Yes. I would change the decoration. I would add racing stripes.”

7th grade male #1 – “Yes. I would make a different wing design. I would make them longer and wider to catch the air and float instead of a sharp stop and then falling.“

7th grade male #2 – “Yes but I would make it lighter and make the wings more flat. Right now they are used paper towel holders”

7th grade male #3 – “Yes. My whole family was involved.”

8th grade female #1 – “Yes. I would make the box not as heavy to make it fly longer.”

8th grade male #1 – “Yes but I would want to see how well the other people’s gliders flew.”

8th grade male #2 – “Yes, I got to work with my dad.”

8th grade female #2 – “Yes, I would but I would put a nose cone on it and try different decorations - something with animals.”

8th grade male #3 – “I would love to do it again. I would change the aerodynamics, like a car, to make it more slick.”

9th grade female #1 – “Yes. I would make it more stable and test it more. I would also change the wings. I would still keep the 2-wing (bi-wing) but make it go through the box to the other side to make them more stable.”

9th grade male #1 – “Yes, maybe.“

9th grade female #2 – “Yes. I would change it though. I would add less weight and balance it out and have not so thick wings.”

9th grade male #2 – “Yes, but I would change partners. I thought I would get the better end of the stick but the girls, who are straight “A” students, didn’t help with the plane design. I would put on a nose cone and use Styrofoam and shape it for the wings. I would also put the wings in the back for more support.”

9th grade male #3 – “I would probably not like to do it again. I’m not into science.”

Interview Question 6: What career field do you think you want to pursue after high school or college?

6th grade male #1 – “I don’t know.”

6th grade male #2 – “Maybe science and engineering.”

6th grade male #3 – “I want to be a rancher.”

6th grade male #4 – “An engineer. This project helped me make a decision. I want to design airplanes or rocket engines.”

6th grade male #5 – “A rancher.”

6th grade female #1 – “I’ve always wanted to be a nurse.”

7th grade female #1 – “A veterinarian.”

7th grade female #2 –“ I would like to be a professional chef.”

7th grade female #3 – “A civil engineer. This project confirmed it.”

7th grade male #1 – “I used to want to work with animals but now I want to work for NASA as an engineer.“

7th grade male #2 – "Before this, I didn't have any idea but now, maybe, an engineer with airplanes."

7th grade male #3 – "A diesel mechanic."

8th grade female #1 – "A beautician."

8th grade male #1 – "I want to be an engineer even before this."

8th grade male #2 – "A rancher but maybe build airplanes too."

8th grade female #2 – "Zoology or marine biology or childcare. I think I will stick with science because it is more interesting."

8th grade male #3 – "Before, I wanted to be a politician but I've changed my thinking into becoming a pilot."

9th grade female #1 – "I want to be a nurse or something to do with animals – animal care taker or doggie day care."

9th grade male #1 – "I would like to be a gunsmith but this challenge kind of goes with gunsmithing. You make a plan and then create it."

9th grade female #2 – "Medicine technologist. I want to stay in the science areas. It shows you how you need to use math in science and to keep good notes."

9th grade male #2 – "I used to want to be a truck driver but now a diesel mechanic or lineman. This project kind of swayed me toward a mechanic because of building the glider."

9th grade male #3 – "I haven't really thought about it but I don't want to design airplanes."

VITA

Lisa Ogle Brown

Candidate for the Degree of

Doctor of Education

Thesis: SOUTH DAKOTA SECONDARY SCHOOL STUDENTS' SCIENCE ATTITUDES AND THE IMPLEMENTATION OF NASA'S DIGITAL LEARNING NETWORK'S "CAN A SHOEBOX FLY? CHALLENGE"

Major Field: Applied Studies - Aviation and Space Science Education

Biographical:

Personal Data: Born in 1970 in Midwest City, OK, married to Christopher C. Brown in December, 2006

Education: Graduated from Alief Elsik High School, Houston, Texas; received Bachelor of Science degree in Animal Science from Texas A&M University, College Station, Texas in 1993; received Master of Education degree in Curriculum and Instruction from the University of Houston, Houston, Texas in 2001; completed requirements for the Doctor of Education degree in Applied Studies - Aviation and Space Science Education from Oklahoma State University in May, 2011.

Experience:
High School Science Teacher - taught at-risk high school students in Alief ISD for 9 years; implemented Career Day for the students

Aerospace Education Specialist for NASA - Responsible for developing and conducting workshops for teachers and administrators in schools, colleges and universities and lecture demonstration programs for students in schools within an eight state region.

Name: Lisa Ogle Brown Date of Degree: May, 2011

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: SOUTH DAKOTA SECONDARY SCHOOL STUDENTS' SCIENCE ATTITUDES AND THE IMPLEMENTATION OF NASA'S DIGITAL LEARNING NETWORK'S "CAN A SHOEBOX FLY? CHALLENGE"

Pages in Study: 112 Candidate for the Degree of Doctor of Education

Major Field: Applied Educational Studies - Aviation and Space Science Option

Scope and Method of Study: The National Aeronautics and Space Administration (NASA) had taken steps to inspire the next generation of explorers through its education programs to enhance student and teacher knowledge of science, technology, engineering, and mathematics (STEM). One of these education programs is the Digital Learning Network (DLN), which uses two-way audio and videoconferencing to share the knowledge and expertise of scientists, engineers, and researchers with students and teachers. The purpose of this study is to assess the degree to which the Digital Learning Network will promote attitudes in the secondary science classroom in a rural town in South Dakota. The DLN's "Can A Shoebox Fly? Challenge" was used to determine if participating in the "Can A Shoebox Fly? Challenge" will create a positive change in attitudes in students in science and, if there was a change, did it differ among genders. Furthermore, this study tried to determine how effective the DLN is with regards to student interest in STEM careers.

Finding and Conclusions: This study utilized a mixed-methods approach to data collection from secondary science students. A parallel pre- and post science attitudes survey, developed by Ingrid Novodvorsky, was used in addition to face-to-face interviews and evidence collected from the students' notebooks. The findings in this study indicate the students' attitude towards science was more positive after the "Can A Shoebox Fly? Challenge" with regards to interest in science class and activities in science class (Factor1); confidence in their ability to do science (Factor 2) as well as their overall interest in science in general. Additionally, both genders showed a positive change in attitudes for the above factors and there was no significant difference between males and females. A negative change in attitudes occurred pertaining to student interest in science-related activities outside of school (Factor 3). The same negative change occurred among males and females with no significant difference between the two genders. The implication of this study provides future research with all of NASA's Digital Learning Network modules to enhance students' interest in STEM careers and STEM student achievement.

ADVISOR'S APPROVAL: Steven K. Marks