Impact of Participation in NASA's Digital Learning Network on Science Attitudes of Rural, Mid-level Students

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Abstract

The purpose of this research was to determine whether videoconferencing combined with face-to-face instruction, as used in the delivery of the NASA Digital Learning Network *Can A Shoebox Fly? Challenge* module, was a feasible instructional method to increase positive student attitudes towards science. Overall, the data indicated that this was the case. This study utilized a mixed method approach to data collection. A pre-test, post-test one group design was used to collect quantitative data obtained from a science attitudinal survey. Qualitative data were gathered from face-to-face interviews with the subjects as well as informal observations by the researcher during the design process. Social presence theory, a sub-area of communication theory, was used as the theoretical framework for this study. It was determined that the NASA Digital Learning Network modules do create social presence within the distance learning environment.

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Introduction

With the fast moving advancement of technology, more and more students are learning through distance education. According to Johnson and Aragon (2002), "distance education is an instructional delivery system that allows students to participate in an educational opportunity without being physically present in the same location as the instructor" (p. 1). The United States Distance Learning Association (USDLA) defines distance learning as "the acquisition of knowledge and skills through mediated information and instruction, encompassing all technologies and other forms of learning at a distance" (2012, p. 1). Distance learning, used with appropriate pedagogy and course design, can assist in the transformation of the traditional classroom to better address the needs of the digital learner (Martin, 2009).

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More opportunities are also being provided for many who may have had limited access to educational experiences and resources prior to the use of this technology, especially rural K-12 students. Ayers (2011) claims that "often, rural schools are at the forefront in using distance technology to provide educational services" (p. 2). Providing rural students with quality science, technology, engineering and mathematics (STEM) instruction can be challenging. However, the National Aeronautics and Space Administration (NASA) has made it easier to link rural students and teachers who may have felt disconnected and isolated to the outside world to NASA engineers, scientists, and resources. According to the U.S. Census Bureau (2010), rural refers to any location or territory that contains less than 2,500 people. This paper offers a descriptive exploration of a partnership between NASA and a rural school where middle school students (grades 6-9) participated in a month-long engineering design challenge.
The state where this study was conducted is ranked as the nation's third most rural state and the highest state with rural schools at 78.6% (Rural School and Community Trust Policy Program, 2012).

Digital Learning Network

The Digital Learning Network (DLN), an educational program of NASA, is one example of distance learning instruction. As part of NASA's Strategic Plan to reach the next generation of explorers, the DLN develops and delivers educational programs and instructional modules that reinforce principles in the STEM areas, especially for students in rural and isolated settings. The DLN seeks to increase content by sharing the knowledge and expertise of NASA scientists, engineers, and researchers with students in K-12 classrooms and encouraging problem-based learning through hands-on engineering design.

The DLN was established in 2004 to provide students and teachers the opportunity to communicate using two-way audio and video technology, linking students and educators with NASA experts (Loston, Steffen, & McGee, 2005). To date, the DLN has reached over one million students and teachers through videoconferencing and webcasts that feature NASA-related, inquiry-centered STEM instruction. However, despite the growing popularity of the usage of the DLN by schools nationwide, the National Research Council (NRC) reported that NASA's educational programs have "weak standards for assessing the educational merits of the modules" (2008, p. 72). Thus, the research in this study focused around one of the learning modules of the DLN. The purpose of this study was to determine if participation in one of the DLN modules that uses videoconferencing, combined with face-to-face problem-based, engineering design impacts students' attitudes about science. Specifically, to what extent will participation in the DLN module *Can a Shoebox Fly? Challenge* impact students' attitudes about and confidence in science?

Theoretical Framework

The advancement of communication and computer technology that supports online learning environments has significantly altered the education of today's youth.

However, despite the rapid advancement and usage of computer technology in learning situations, there is concern about the effectiveness of this instructional tool. There have been studies when comparing traditional face-to-face instruction with technology-driven instruction that found no significant differences on educational variables such as learning outcomes and student satisfaction (Clarke, 1999; Johnson, Aragon, Shaik, & Palma-Rivas, 2000; Navarro & Shoemaker, 1999; Smeaton & Keogh, 1999). From these studies it could be concluded that technology instruction has little impact on students' attainment of educational outcomes. Many in the field of instructional technology conclude that instructional factors such as effective pedagogical strategies and course design are more important than the type of technology being used as the delivery system (Phipps & Merisotis, 1999). As stated by Schramm (1977), "learning seems to be affected more by what is delivered than by the delivery medium" (p. 273).

Social presence theory

According to Wheeler (2005), research into student perceptions of technology supported learning is limited. Social presence theory, a sub-area of communication theory, argues that a critical factor of a communication medium is its 'social presence,' defined as the degree of importance of the other person in the interaction and the resulting interpersonal relationship (Short, Williams, & Christie, 1976). Social presence theory is now recognized as a central concept in distance learning environments (Lowenthal, 2010) and is listed as a key component in theoretical frameworks for learning networks (Benbunan-Fich, Hiltz, & Harasim, 2005) and distance education (Vrasidas & Glass, 2002). Researchers have shown varied relationships between social presence and student satisfaction (Gunawardena, 1995; Gunawardena & Zittle, 1997; Richardson & Swan, 2003), development of a community of learners (Rourke, Anderson, Garrison, & Archer, 2001; Rovai, 2002), and perceived learning (Richardson & Swan, 2003).

Social presence represents the perception that an individual communicates with others rather than inanimate objects, despite being located in different places. Central to social presence theory is the ability of learners to work together effectively in groups. As expressed by Wheeler (2005), "when social presence is low, group members feel disconnected and group dynamics suffer. Conversely, when social presence is high, members should feel more engaged and involved in group processes" (p. 3). In addition, Stein and Wanstreet (2003) state that a learning group with high social presence will more easily substitute technology mediated communication for face-to-face communication. This is especially important to educators who desire to deliver educational programs using computer technology.

Literature Review

Distance education

G. Greenberg (1998) defines contemporary distance learning as "a planned teaching/learning experience that uses a wide spectrum of technologies to reach learners at a distance and is designed to encourage learner interaction and certification of learning" (p. 36). Teaster and Blieszner (1999) say that "the term distance learning has been applied to many instructional methods; however, its primary distinction is that the teacher and the learner are separate in space and possibly time" (p. 741). Some research has been conducted on learners' reactions to and attitudes about distance learning with varying results. A survey conducted by Barron (1987) of college-aged students taking distance education courses found that these students preferred to be in a traditional face-to-face classroom. Other studies have reported that college students felt less focused in distance education classes than in traditional classes (Barker & Platten, 1988). However, Egan, Welch, Page, and Sebastian (1992) reported no significant differences in interest between college students enrolled in a distance special education methods class and a traditional face-to-face classroom. A meta-analysis done by Allen, Bourhis, Burrell, and Mabry (2002) indicated a slight student preference for traditional classroom instruction over a distance learning format, yet little difference in student satisfaction. According to Glenn (2001), 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). Glenn's study, comparing college students enrolled in an on-campus political science course to those enrolled in the same course delivered by distance learning, found no statistically significant difference in student perceptions.

Some research has also been conducted regarding the relationship of distance learning to student achievement. A study by Ingebritsen and Flickinger (1998) reported that college students enrolled in an on-line biology course had slightly higher grades than students in the same biology course delivered face-to-face. A meta-analysis by Machtmes and Asher (2000) indicated little difference in the academic improvement of students involved in traditional face-to-face instruction compared to distance learning. Further, a meta-analysis by Cavanaugh (2001) supports "the use of interactive distance education to complement, enhance, and expand education options because distance education can be expected to result in achievement at least comparable to traditional instruction in most academic circumstances" (p. 80).

Videoconferencing, as a form of distance learning, promotes interaction in the classroom and can provide opportunities for students to present authentic research and findings and obtain valuable feedback from peers, teachers, and scientists (Alhalabi, Anadaptuam, & Hamza, 1998; Amirian, 2003; Heath & Holznagel, 2002; Sherry, 1996). According to a report by A. Greenberg (2004), the research shows that:

> Interactive videoconferencing technology can be an extremely effective medium for delivering quality education to a broad, geographically dispersed student population….and that the technology has helped governments address mandates for economic and infrastructure development (not to mention internal agency training), helped universities follow mandates for educational outreach, and helped colleges, universities, and secondary schools reach out to vastly expanded student populations while also finding new sources of content and expertise. (p. 4)

Greenberg, in a review of multiple research studies, further concluded that videoconferencing is as effective as "traditional classroom instruction, fosters interactivity in learning situations and is most effective when teachers design the instruction around the videoconferencing to be interactive, increases access of certain populations to education, can be cost effective, and accommodates multiple learning styles" (2004, p. 2).

Videoconferencing also allows for expanded educational opportunities to students in isolated, rural schools. By providing these opportunities, rural students are exposed to a global world that might not otherwise be possible while living in remote locations (Motamedi, 2001). Irele (1999) concluded that videoconferencing enables remote learners to be part of a larger social environment. Further, Boone (1996) stated that "science education should expand its use of distance education technology" and that "this technology seems to be one way in which more individuals of all ages can be exposed to science" (p. 45).

Student attitudes and achievement

Research has shown that positive attitudes towards and interest in science are important for learning to occur. According to Novodvorsky (1993), when students have positive attitudes towards science, there is a greater likelihood that they will become "scientifically literate adults who will be able to make rational decisions about science-related issues" (p. 27). Numerous studies have been conducted to examine the correlated relationships between science attitudes and achievement in science and these studies indicate that one does influence the other (Castsambis, 1995; Reynolds & Walberg, 1992; Simpson & Oliver, 1990; Stienkamp & Maehr, 1983; Wilson, 1983). Oliver (1986) conducted a longitudinal study with adolescents correlating attitudes toward science, achievement motivation, and science self-concept as predictors of achievement and concluded that "attitudes 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 college students enrolled in an introductory physics course who have more favorable attitudes towards science are more likely to have higher achievement. Their study indicated a positive correlation between science attitudes and conceptual learning gains. The results of a study of middle school students done by Hsieh, Cho, Shallert, and Liu (2008) indicated a "strong positive relationship between students' self-efficacy and student achievement in a technology-rich, self-directed environment" ((p. 46). Finally, Osbourne, Simon, and Collins (2003) recognized that one of the components of an effective science class includes hands-on inquiry activities and thus concluded that inquiry should play a positive part in influencing student attitudes.

Some studies have studied the relationship of gender with science attitudes and achievement. In a study by Sorge (2007) with students ages 9-14, differences in attitudes to science were assessed and a significant relationship between age and attitude toward science was found. The students' science attitude mean scores decreased significantly between the elementary and middle school transition. Catsambis (1995) examined gender differences in attitudes and science achievement with middle school students. Findings showed that middle school females were not lagging behind their male peers in science achievement but they did have less positive attitudes toward science and 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. Eighteen studies were reviewed and it was determined that the correlation was positive for both males and females but stronger for females in both biology and physics.

Furthermore, research has shown that positive attitudes towards distance education affects academic achievement. A study by Mustafa (2012) determined that freshman students at Nizwa College of Technology who took an English core course using web-assisted technology achieved higher test scores than those in the traditional class. It was also found that students in the experimental class reported greater positive preferences for and attitudes towards technology integration in their class. Research by Gero, Zoabi, and Sabag (2012) indicated significant higher scores on a standardized exam of students studying the subject of the transistor through animation as compared to the scores of their colleagues who studied it using static diagrams. Their research also showed that students who studied about the transistor through animation expressed significantly more positive attitudes towards electronics than their peers. Akcay, Durmaz, Tuysuz, and Feyz (2006) compared the effects of computer-based learning and traditional face-to-face instruction on college students' attitudes towards and achievement in analytical chemistry. Analytical chemistry achievement and positive attitudes towards chemistry in the experimental group were significantly higher from the control group.

Despite the interest in and research regarding distance learning instruction as well as the relationship between student attitudes and achievement, there has been limited research correlating distance learning instruction with student attitudes towards science. Thus, the authors of this study chose to investigate the following research question: What impact does science instruction delivered by distance learning, specifically videoconferencing, combined with traditional face-to-face instruction have on attitudinal change of mid-level students about science?

Methodology

This study utilized a mixed methods approach to data collection. A pre-test, post-test one group design (Creswell, 2003) was used to collect quantitative data obtained from a science attitudinal survey. Qualitative data were gathered from: a) face-to-face interviews conducted after the second DLN videoconferencing, b) composition science notebooks that the participants kept throughout the design process between the two videoconferencing sessions, and c) informal observations made by the researcher during the design orientation at the first videoconferencing period and the design sharing during the second videoconferencing. The data collected from each participant included Form A (pre) science attitudes survey, Form B (post) science attitudes survey, the researcher's notes from the face-to-face interviews and informal observations, and the student composition notebooks which contained their glider research and data.

Participants

The 55 participants in this study were enrolled in mid-level science classes (grades 6^{th}-9^{th}) in a small rural school district located in the upper mid-west of the United

States. The school district covers over 2000 square miles and most of the community economics involve farming, ranching, and tourism. At the time of this study (2009-2010 academic year), the school district employed approximately 80 staff members and had a total of 350 students enrolled across two district schools – an elementary school (K-8) and a high school (9-12) – both designated as Title 1 schools. The total student population of the district included 43% Native American, 56% Caucasian, and 0.5% Asian, with 46% males and 54% females.

There were 89 total students (31 in grade 9) enrolled in the rural high school where the demographics included 51 Caucasian students; 37 Native American students; 1 Asian/Pacific Islander students; and no African American and Hispanic students. The elementary school had 203 total students with 63 in grades 6-8 (22 in sixth grade, 23 in seventh grade, and 18 in eighth grade). The demographics for the entire elementary school included 100 Caucasian students; 102 Native American students; 1 Asian/Pacific Islander; and no African American and Hispanic students. Because of the small size of the rural high school and thus, low enrollments in each subject and grade level, it was decided to include students in the middle grade levels at the elementary school to participate together in the DLN module.

The total population pool for this study was ninety-four students in 6th-9th grades. However, 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 such as sports or band competitions. The participants were purposively selected based on their required enrollment in grade level specific science classes (6^{th} grade = 12 female and 9 male; 7^{th} grade = 4 female and 2 male; 8^{th} grade = 8 female and 10 male; 9^{th} grade = 6 female and 4 male). No other demographic information was obtained because it would compromise assurances of confidentiality to research participants.

In 2006, this district was chosen as a NASA Explorer School, one of 26 school districts chosen to participate in a 3-year partnership with NASA. As a result of this designation, NASA supported two to four onsite visits each year by an Aerospace Education Specialist to train the teachers in the district at the two school sites in the use of NASA curricula and resources. The participants in this study had had no exposure to the NASA Digital Learning Network modules previously, but had been exposed to other NASA educational curricula in the classroom by their teachers as well as site visits and interactions with the NASA Aerospace Education Specialist.

Context of the Study

According to Johnson and Aragon (2002), "context is an essential central element in learning because knowledge is a product of the activity, context, and culture in which it is developed and used" (p. 4). There are three major elements of situational context and how these affect knowing and learning, as identified by Wilson (1993). The first is that thinking and learning are social activities dependent on interpersonal interactions. Second, the tools available during the learning activity impact the learner's ability to learn. And third, "human thinking is profoundly structured by interaction with the setting" (Wilson, 1993, p. 72). The situation for this study incorporated all three contextual elements to promote learning in the virtual classroom. These included students working in cooperative groups involved in problem-based learning and engineering design and direct interactions with teachers face-to-face and science experts through distance instruction.

The DLN challenge activities use engineering principles as the vehicle for science teachers to meet many of the national and state science and technology standards. The principles of engineering are introduced through Project-Based Learning (PBL) involving real problems and real problem solving, the essential aspects of engineering design (see Figure 1). Asunda and Hill (2008) describe engineering design as the "process of devising something. It is creative, iterative and often open-ended process of conceiving and developing components, systems, and processes" (p. 26). The DLN activities address the content standards in science and technology, as they create connections between the scientific concepts learned in the classroom and those used in engineering applications in the modern workplace. The DLN activities also offer students the opportunity to experience the design process while simultaneously being introduced to the laws of science through their understanding of how objects and systems work. According to Schunn (2011), design challenges should:

a. Involve systems that emphasize key science learning goals.
b. Allow for flexibility in choice of target goals.
c. Involve collaboration.
d. Be divided into subsystems.
e. Set high expectations.
f. Require reflective presentations rather than just the construction of prototypes or demonstrations of prototype functionality

The DLN Challenge that students participated in for this study lent itself to these principles in that the students: a) had been learning science since starting school and had practiced many of the process skills needed for a successful design, b) were given open-ended choices of materials and collaboration (i.e. work in groups or individually), c) worked on subsystems rather than the entire product at once, d) achieved awards and recognition for various categories in the final demonstrations, and e) made formal presentations to a NASA DLN Education Specialist and were prepared to answer design questions.

The students selected for this study participated in NASA's DLN module *Can A Shoebox Fly? Challenge* that occurred during and between two videoconferencing sessions over a four-week period. The two science teachers were present during both videoconferences as observers. The researcher, a NASA Aerospace Education Specialist based out of Johnson Space Center and completing a doctoral degree in Aerospace Education, was also present to facilitate the engineering design process and the communication between the students and the DLN Education Specialist from the NASA Ames Research Center in Sunnyvale, CA.

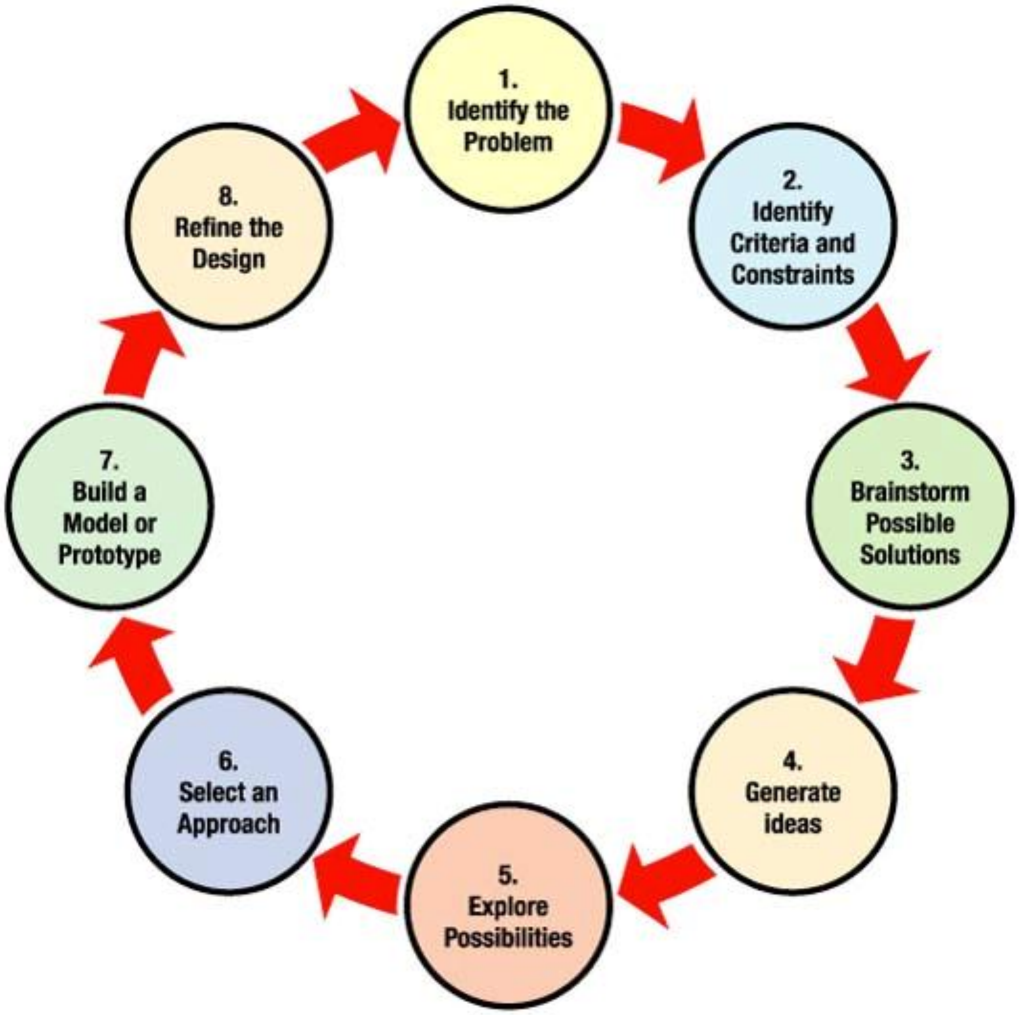

Figure 1 – Engineering Design Process

The first DLN videoconference event was approximately one hour in duration. The DLN Education Specialist showed the students videos of NASA's Helios airplane and an airfoil in a water tank. In addition, the Specialist facilitated the construction of the wing-on-a-string paper model as the students constructed a paper model of a simple single wing design using paper, tape, straw, and string provided to the students. In this hands-on activity, students experienced 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 and discuss wing design with the DLN Education Specialist as well as the researcher during the DLN videoconference.

The students were next presented a design challenge by the DLN Specialist to build a glider out of an ordinary shoebox. They were given criteria and constraints for their design (see Appendix 1) to simulate what occurs in real-world engineering applications. The Challenge criteria were that: 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, and d) design teams must prepare a final presentation of results and understanding. The design constraints also given to the students were that: a) the glider must include an intact shoebox in its design, b) the glider must be built out of recycled materials, and c) students had a time limit of one month to research, build, and test the glider. The students were given the choice of working on their glider individually or in cooperative groups based on their own learning styles.

During a four-week interval, the students worked through the engineering design process mainly out of school; however, they were able to discuss their own challenges during class time with other classmates. The two science teachers were available to aid in the students' research but stated most of the students did not ask them for assistance. The researcher was not on-site to answer student questions during this time frame.

Four weeks after the first videoconferencing session, the student teams participated in a second videoconference where they presented their gliders and design results to the researcher (on-site) and the DLN Education Specialist (on-line). Each team described what materials were used, changes and modifications were made, thought processes and scientific thinking were behind these changes, and final design results. The DLN Education Specialist asked questions of each team regarding the performance of the glider and the choices of material used.

Instrument

The survey instrument used in this study was a 36-question science attitudinal survey developed by Novodvorsky (1993) for research with secondary students. This instrument uses a Likert-5 scale with the respondent choosing one of five responses ranging from strongly disagree to strongly agree. The attitudinal survey uses two forms - Form A (pre-test) and Form B (post-test) - which are parallel forms of each other and contain questions that attempt to determine students' attitudes towards science (see Appendix 3). The two parallel forms allow 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). Novodvorsky (1993) determined test-retest correlation coefficients to be 0.780 for Form A and 0.783 for Form B, parallel-forms reliability coefficients of 0.875 for the first administration and 0.885 for the second, and inter-item consistency coefficients of 0.925 and 0.923 for the two administrations of Form A and 0.905 and 0.906 for the two administrations of Form B.

Form A of the science attitudinal survey and administrative instructions were emailed to the classroom science teachers prior to the first DLN event. These teachers administered and collected Form A from their students during science classes before the first videoconferencing event. Form B of the science attitudinal survey was administered and collected by the same teachers immediately after the completion of the second DLN event.

Science Notebooks

All of the students in grades 6-9 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. After the second DLN videoconference, the students' composition notebooks were collected and reviewed for evidence of their participation in the engineering design process. The notebooks were first submitted to the science teachers to be graded. After the two science teachers graded the notebooks, the notebooks of the 55 study participants were returned to the researcher for insight into their learning process. A total of twenty-six notebooks were reviewed as some students worked in groups and only one notebook was submitted per group.

Interviews

Qualitative data were collected from face-to-face interviews by the researcher. Twenty-two of the 55 participants volunteered to be interviewed. The demographic breakdown of these students were:

6^{th} grade = 6 students (1 female and 5 male)
7^{th} grade = 6 students (3 female and 3 male)
8^{th} grade = 5 students (2 female and 3 male)
9^{th} grade = 5 students (2 female and 3 male)

The interviews were conducted separately by the researcher in a one-on-one context in a closed room, occurring on the same day of the second videoconferencing experience. Each interview lasted approximately 20 minutes and the interviews were not video or audio taped. The researcher hand recorded the students' responses. Each participant answered the following questions 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?

Data Analysis

Quantitative data were collected using a pre-test (Form A) and a post-test (Form B) of a science attitudinal survey. Each survey allowed for the questions to be grouped based on three factors identified by Novodvorsky. These 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

Because of the large number of variables identified, a Principal Component Analysis (PCA) was performed to reduce the number of observable variables into principal components. Principal Component Analysis is a data analysis method that reduces the number of data dimensionally by performing a covariance analysis between factors and is a tool used to uncover unknown trends in data (Jolliffe, 2002, p. ix). The PCA resulted in a smaller number of variables that accounted for the variance in 79 observable variables that represented the students' four-digit assigned number, gender, grade level, two unused sources of data (notebooks and interviews), and responses from 36 questions from Form A and Form B of the science attitudinal survey. The PCA variable accounted for 94.0% of the variance in the pre-survey (Form A) and 93.8% of the variance in the post-survey (Form B). These results indicated that the variables do measure the students' interest towards science in general.

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 as H0: Form A = Form B. The t-test assumes Normality of the underlying scores. The Shapiro-Wilk Test of Normality was used to determine whether the distribution's deviation from Normality was of concern (Shapiro & Wilk, 1965). 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.

Qualitative data collected from each participant included the researcher's notes from the face-to-face interviews and informal observations and the student composition notebooks. All data were analyzed by one researcher. The interview questions were pre-determined by the researcher and analyzed according to the participants' answers to those questions. The composition notebook entries were analyzed by the researcher around the identified steps in the engineering design process.

Findings

Attitudinal survey

When comparing the pre/post mean 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 had a positive change in attitudes towards science after completing the NASA Digital Learning Network *Can A Shoebox Fly? Challenge* module.

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 classes and activities in science classes. Strong statistical evidence exists that students had a positive change towards Factor 1 (Interest in science classes and activities in science classes) after completing the *Can a Shoebox Fly? Challenge* module (t = 4.6382; df = 44; p<0.0001) (see Table 1).

There is also high confidence that the PCA scores (Form A = 94.1% and Form B = 94.6%) measure the attitudes of the students' confidence in ability to do science. Students had a statistically significant positive change towards Factor 2 (confidence in ability to do science) after completing *Can a Shoebox Fly? Challenge* module (t = 9.9946; df = 44; p<0.0001) (see Table 1).

Likewise, there is high confidence that the PCA scores (Form A = 93.5% and Form B = 92.8%) measure the underlying attitudes of the students' interest in science-related activities outside of school. However, in contrast to the results for Factors 1 and 2, there is a statistically significant relationship that the *Can a Shoebox Fly? Challenge* module caused the attitudes of the students toward Factor 3 (interest in science-related activities outside of school) to decline (t = 4.4752; df = 44; p<0.002114) (see Table 1).

Table 1. *Summary of Form A and Form B Attitudes Survey Analysis*

Factor	Overall t	Overall df	Overall p
Factor 1	4.6382	44	significant
Factor 2	9.9946	44	significant
Factor 3	4.4752	44,	significant

The science attitudinal survey developed by Novodvorsky (1993) was based on high school student responses. The reliability coefficient of this instrument in that study was 0.93 and the construct validity was 0.82. Because the researcher of this study used Novodvorsky’s survey with middle school students (6th-9th grades), a Chronbach’s alpha was calculated for each of the Factors to measure the internal reliability of each factor based on this different student population. The results indicate the instrument maintains its reliability with students in grades 6 -9. In addition an overall Chronbach coefficient of 0.8884 was calculated for Form A and 0.8821 for Form B (see Table 2).

Table 2. *Chronbach’s Alpha for Factors on Science Attitudinal Survey*

Factor	Form A alpha	Form B alpha
Factor 1	0.8594	0.7596
Factor 2	0.7598	0.7172
Factor 3	0.6637	0.7472
Overall	0.8884	0.8821

Interviews

Twenty-two students who volunteered were interviewed to obtain descriptions about their DLN module experience and their attitudes towards STEM careers. The face-to-face interviews conducted one-on-one with the researcher sought additional insight into their attitudes towards their learning experience using the DLN module. All students were asked the following pre-determined questions in the same order. Excerpts from the interviews are presented for each 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?*

All students interviewed indicated that they liked learning with the DLN module. The students did not express preference about how they learned; however, they would have preferred to have more opportunities to ask the DLN Education Specialist questions during the shoebox/glider design process between the two videoconferencing sessions.

> 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 #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."

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

All of the students interviewed expressed positive attitudes about learning using the engineering design process. The students were given an opportunity to apply their prior knowledge about flight, generate new ideas and possibilities, and design a product that would satisfy the criteria and constraints of NASA's *Can A Shoebox Fly? Challenge.* Over half of the participants highlighted that they enjoyed working with a peer as a partner, and five students talked about partnering with a family member.

> 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 #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."

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

All of the students interviewed liked the challenge; eight of the students did not have anything negative to say about the experience. However, some students expressed initial frustration with the engineering challenge of designing a shoebox to glide. Yet, the students did state that this initial frustration became minimal when success was achieved.

> 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 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."

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

All of the students indicated that the hardest part of the module dealt with some aspect of the engineering design process where they 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 to the aerodynamics.

> 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."
>
> 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."

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

Only one student (6th grade female) expressed that she would not want to do *Can a Shoebox Fly? Challenge* again, yet she gave no concrete reason. Three of the students highlighted their involvement with family members as a reason for doing the activity again. Twenty-one of the students interviewed agreed that they would like to do the challenge again, but that they would make some changes to their original design.

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

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 stated they would like to pursue a STEM career and six (27%) students stated they would pursue careers where a science and engineering background would be beneficial in their career choices (mechanic, pilot, and rancher). Four students emphatically stated they were swayed towards pursuing a STEM career due to participating in the DLN module.

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."

Science Notebook Entries

Excerpts from the students' notebooks are below (see Table 3) and are offered as examples of their learning through the steps of the engineering design process (see Appendix 2) using the medium of *"Can a Shoebox Fly? Challenge."* The students began by defining the problem (converting the shoebox into a glider) and brainstorming possibilities of design given the criteria and constraints. The students next began to research and construct prototypes. Then, as they tested their gliders, they re-examined and revised their designs. One particular challenge for these rural students was finding an ample supply of recycled materials in their small community. One group used excess siding from a construction project at home while another group searched the town dump and found long pieces of Styrofoam to use as wings.

Table 3. Notebook Entries Correlated to Engineering Design Steps

Engineering Design Process Steps	**6th grade female**	**6th grade male**
Identify the Problem	How can I design a __________ that will __________?	
Identify Criteria and Constraints	Criteria • The glider must move forward at least three meters. • The glider must demonstrate an effective positive glide slope ratio. • The glider must not break upon landing. • Teams/Individuals will prepare a final presentation of results and understanding.	Constraints • The glider must include an in-tack shoebox in its design. • The glider must be built out of recycled materials. • Time limit of one month to research, build, and test the glider.
Brainstorm Possible Solutions	*I ripped off the top of the shoebox so that when it is gliding, it will go farther because of the less*	*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*

Generate Ideas	*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.*	*fly better without the lid- it went a little farther.*
Explore Possibilities **Select an Approach**	*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!"*	*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*
Build a Model or Prototype	*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!"*	*I added wings to the bottom and taped them on and added two beams connected to the top to support the wings. 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.*
Refine the Design	*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…."*	*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 "*

Discussion

The specific purpose of this research was to determine whether videoconferencing combined with face-to-face instruction, as used in the delivery of the NASA Digital Learning Network's *Can A Shoebox Fly? Challenge* module, was a feasible instructional method to increase positive student attitudes towards science. Overall, the data indicated that this was the case. Results for Factors 1 and 2 (Factor 1 - Interest in science classes and activities in science class; Factor 2 - Confidence in ability to do science) indicated a significant positive change in science attitudes after completing the Digital Learning Network's *Can A Shoebox Fly? Challenge* module. The DLN allowed the students, in collaboration with peers, to share their findings with NASA experts and provided them ownership of their learning. However, findings for Factor 3, interest in science-related activities outside of school, indicated a negative change after completing the challenge. The decline in science attitudes for Factor 3 was supported by the interviews where some students expressed a lack of support during the shoebox construction that led to them being frustrated and less motivated to complete the shoebox glider. Several students worked on their designs with family members and peers outside of class, but not all of them had that opportunity. In the interviews, students expressed frustration in not being able to ask questions and interact with NASA experts during the design process of their glider. Perhaps if they had been able to do so, the survey data may not have shown a decline in Factor 3. A recommendation for NASA's Digital Learning Network curricula would be to provide opportunities for the students to interact with NASA scientists during the design process itself. A blog format or some other form of social online discussion is recommended to accompany the DLN modules. It would not take away instruction time from the teacher or students and the students could blog from home, potentially involving parents.

In addition, the quantitative data gathered from the science attitudinal survey suggest no significant difference in science attitudes among males and females. Both genders showed a positive change for Factors 1 and 2. Conversely, the data for Factor 3 showed a negative change in science attitudes of both male and female students towards interest in science-related activities outside of school.

Based on the level of peer interactions observed by the researcher during the videoconferencing sessions, discussions with the students during the single wing design, and interviews with students, it was concluded that the majority of the students had a positive experience in their participation in the *Can A Shoebox Fly? Challenge* module. 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 until they were satisfied with the performance of their glider. The interviews supported the idea that the students had experiences in the iterative cycle of engineering design, continually making changes to their glider design for improvement of flight.

In addition, based on the review of the notebooks, it was determined that most of the students were able to demonstrate their ability to collaborate with their peers and articulate their thoughts effectively, both components of contextual situations that promote learning in a virtual classroom. However, most of the students interviewed expressed frustration about documenting their design changes and results in their notebooks. The authors believe this frustration was due to the lack of prior experiences of the students in documenting their research. One recommendation for the implementation of DLN modules would be for the teacher to give instructions beforehand to the students on how to document qualitative and quantitative observations appropriately.

According to Amirian (2002), interaction is critical in distance learning, such as in the structure of the DLN modules, because "interaction is the key component of this use of the technology to support a more social learning, negotiating meaning through interaction with peers over distance, and forming a sense of community using the technology" (p.1). The DLN module provided an interactive delivery method that allowed two-way communication between students in a small isolated community with a DLN Education Specialist at the NASA Ames Research Center. While there are some disadvantages regarding the usage of videoconferencing in educational settings, such as network issues, start-up costs, and change in time zones, videoconferencing does not appear to hinder the ability to enhance hands-on problem-solving opportunities for students. In fact, the data in this study indicated the opposite. The NASA Digital Learning Network modules illustrate how electronic technology can support collaboration and promote learning.

Teachers should feel confident that using distance education, especially if it includes interactive activities, has the potential of providing more diverse learning opportunities to their students, especially those is rural and isolated settings. Bringing science experts into the classroom via videoconferencing can provide real-world examples, applications, and concepts to students. Thus, according to Martin (2009), videoconferencing "can address the new needs of digital learners and help prepare them for the new market place, as well as being inclusive of the needs of learners with special needs and of teachers-as-learners" (p. 3973).

The NASA Digital Learning Network modules do create social presence within the distance learning environment. The use of videoconferencing minimizes potential feelings of social isolation of the remote learners as they are able to have their questions answered by the experts during the actual videoconferencing periods. Students work collaboratively with their peers within an environment that encourages the sharing of ideas. They are encouraged to participate in discussions and activities in order to gain feedback from their peers, their teachers, and the NASA scientists and experts during the videoconferencing experience. This encouragement and participation created an environment in which a connectedness between students and mentors was possible. However, as stated before, one recommendation for NASA's Digital Learning Network curricula would be to provide opportunities for the students to interact with NASA scientists during the design process itself to continue the social presence established during the videoconferencing.

A review of the literature indicated that limited research has been done regarding the NASA Digital Learning Network curricula and the effectiveness of its delivery methods. Further research needs to be conducted regarding the DLN and its modules on how student participation in its curricula impact student attitudes towards science, STEM career choices and science achievement. This study used a one group, pre-test, post-test design due to the small, isolated nature of the population and as a result, created limitations to the data analysis and generalizability of the results. Other factors could have influenced the results garnered from the pre/post survey scores. In addition, the small number of subjects in this study also limits the generalizability of the results to other populations of mid-level students in other settings. Thus, research regarding the DLN modules needs to be conducted utilizing a larger population of students in similar control and treatment groups for greater validity.

Interaction among participants is critical in learning and cognitive development (Sharan, 1980; Slavin, 1983). Sociocognitive theorists describe learning as an interactive group process in which learners actively construct knowledge and then build upon that knowledge through the exchange of ideas with others (Harasim, 1990; Vygotsky, 1978). These theories combined with the findings of this study indicate that the social aspects of learning should be incorporated into both the design and delivery of distance education.

Educational activities today are not confined by text, print based materials, time or space. Educators are challenged to develop appropriate strategies to deal with increasingly new information and communication technology that are impacting previously recognized ways of teaching and learning. The authors of this article agree with Clayton (2007) that "those features explored in learning environment research, the perceptions of students and teachers of the environment, the social and psychological factors, will be as equally important to research in digital environments" (p. 165). More research needs to be conducted in both online educational environments and traditional educational environments to determine the extent that perceptions of social presence influence student satisfaction, student motivation and other attitudinal factors as well as students' actual cognitive and affective learning.

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Appendix 1**.**
Can A Shoebox Fly? Challenge

Here is your Challenge:
Produce a design that incorporates a shoebox as part of your glider. Additionally your Shoebox Glider will have to meet the criteria and constraints partially listed below. Your Challenge is open-ended and involves a variety of collaborative and creative problem solving efforts!
As part of your challenge, you will need to accomplish the following tasks:

- Research the dynamics of flight and apply them to your efforts.
- Determine and gather the materials you will need for your glider.
- Determine how to launch the shoebox glider in a consistent way.
- Obtain the most efficient glide slope ratio possible.
- Demonstrate your understanding and success to NASA

Guidelines
1. Write the words "criteria and constraints" on the board. Ask students to define the terms. Explain that when designing any device, the inventor/engineer must consider criteria and constraints.

*The students should understand that **criteria** are standards or requirements that the device must include. Examples of criteria are that the device must be efficient, must be able to land gently, and must be able to glide a certain distance.*
***Constraints** are things that limit the design of the glider. Examples of constraints are money, time, maximum size, available materials, space to build or fly, and human capabilities.*

2. Under the title: "Shoebox Glider Criteria" write the following:

a. The glider must move forward for at least 3 meters.
b. The glider must demonstrate an efficient positive glide slope ratio.
c. The glider must not break upon landing.
d. The glider's glide slope and aspect ratios must be determined.
e. Teams will prepare a final presentation of results and understanding based on the scoring rubric.

3. Under the title: "Shoebox Glider Constraints" write the following:

a. The glider must include an intact shoebox in its design. Final team presentations will be limited by time, depending on the number of total presentations. Usually 5 to 6 minutes.

4. Using provided and any additional resources students can begin background research, gathering materials, designing, and construction.

Peer Evaluations
1. After student teams have completed their research and designs, have different groups switch design plans and evaluate each other's proposals.
2. In this evaluation process, the groups should focus on whether the design

meets the criteria and constraints up to this point and to offer any constructive criticisms or suggestions that would lead to greater success.

3. Once the groups have shared their evaluations, discuss as a class what the students learned from this peer evaluation. Lead a discussion using the following questions:
   a. Did your glider design meet the criteria and constraints?
   b. What changes would you make and why?
   c. What helpful comments did you get from the other group?

4. Explain to the students that an important part of the design process is revising the designs prior and during flight-testing.

Preparing for Flight Tests

1. After making improvements, the teams should be ready to test their shoebox gliders. *Note to teacher: A large space will be needed where the gliders can be tested. Outside or in your school's gym might be a great place to test them.*

2. Have teams keep records of designs, research, peer evaluations, changes made, what problems they had to solve during the design process and how they solved those problems.

3. Based on the scoring rubric have the students be responsible for gathering and recording the following data: how high the glider was released from (altitude), the distance it covered, calculating glide slope and graphing these results, determining the glider's aspect ratio, and total time aloft.

Flight Testing

1. Explain that the teams are now going to compete against each other to determine which glider is the most efficient in terms of glide slope. A glide slope is a method of making a standardized comparison of each team's efforts regardless of the height a team's glider was released from or the distance it covered. Discuss that there is not a perfect design, but scientists and engineers do look for the design that is the most efficient.

2. Discuss with the students that sometimes tradeoffs have to be made among features (aerodynamics, stress, and weight) in order to make the glider the most efficient. Ask students to identify and record any tradeoffs that they make to their gliders during their flight tests.

3. Have teams run as many flight tests as possible during the time constraints set by the classroom teacher. The data from the test flights can then be averaged, or the best one used.

4. Have the students compare the data of their original test flight to their later or best flight to monitor improvements in efficiency.

5. As a class, decide which gliders are the most efficient in terms of the glide slope data obtained from their flight tests. Discuss with the students that this does not mean this is the perfect design.

Discussion/Wrap-up and Team Presentations

1. Have the students explain the steps they went through to design their shoebox gliders. Ask the students if they think scientists and engineers follow similar steps. After the students have shared their ideas, explain that the students followed a very similar process to that of design engineers.

2. Explain that the basic design process includes: defining a problem, specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or building it, and communicating the process and results to others.

3. Using the scoring rubrics for "PowerPoint Visual Design" and "Final Student Presentation" as a guide, select the best student teams to prepare a 5 to 6 minute visual-oral presentation for NASA of their flight test results, understanding of flight dynamics, and problem solving process.

Student Team Presentations

Student teams are selected to present to NASA's DLN

1.Classroom Teachers and NASA Educational Host, along with Rubric results, can be used to determine which student teams will present their results during the second DLN connection. The remaining student teams will be passive participants.

2. Student Presentation Requirements. Each team has 5 to 6 minutes to present the following items and information:

- The actual experimental Shoebox Glider
- Visual of its flight (images in sequence, video, MPEG, etc.)
- Recorded Distance and Height of flight
- Calculated Glide Slope = D/H
- Calculated Aspect Ratio = L/W
- Interpretation of Glide Slope w/ graph of slope
- Interpretation of any relationships between Glide Slope and Aspect Ratios

NASA, D. L. N. (2004). *Can a shoebox fly? challenge- a digital learning network experience for grades 5-12.* Retrieved from http://www.nasa.gov/pdf/582954main_Shoebox Teacher Guide.pdf

Appendix 2.
Engineering Design Process Steps

1: Identify the Problem -- Students should state the challenge problem in their own words. Example: How can I design a **__________** that will **__________**?

2: Identify Criteria and Constraints -- Students should specify the design requirements (criteria). Example: Our growth chamber must have a growing surface of 10 square feet and have a delivery volume of 3 cubic feet or less. Students should list the limits on the design due to available resources and the environment (constraints).

3: Brainstorm Possible Solutions -- Each student in the group should sketch his or her own ideas as the group discusses ways to solve the problem. Labels and arrows should be included to identify parts and how they might move. These drawings should be quick and brief.

4: Generate Ideas -- In this step, each student should develop two or three ideas more thoroughly. Students should create new drawings that are orthographic projections (multiple views showing the top, front and one side) and isometric drawings (three-dimensional depiction). These are to be drawn neatly, using rulers to draw straight lines and to make parts proportional. Parts and measurements should be labeled clearly.

5: Explore Possibilities -- The developed ideas should be shared and discussed among the team members. Students should record pros and cons of each design idea directly on the paper next to the drawings.

6: Select an Approach -- Students should work in teams and identify the design that appears to solve the problem the best. Students should write a statement that describes why they chose the solution. This should include some reference to the criteria and constraints identified above.

7: Build a Model or Prototype -- Students will construct a full-size or scale model based on their drawings. The teacher will help identify and acquire appropriate modeling materials and tools. See the design brief for a sample list.

8: Refine the Design -- Students will examine and evaluate their prototypes or designs based on the criteria and constraints. Groups may enlist students from other groups to review the solution and help identify changes that need to be made.

Appendix 3.
Novodvorsky Science Attitudinal Survey

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.					

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.					