

THE INFLUENCE OF THE HIGH SCHOOL STUDENTS UNITED WITH NASA  
TO CREATE HARDWARE (HUNCH) PROGRAM ON STUDENT MOTIVATION  
TO STUDY AND PURSUE CAREERS IN SCIENCE, TECHNOLOGY,  
ENGINEERING, AND MATHEMATICS (STEM)

By

Florence Ray Gold

A dissertation submitted in partial fulfillment  
of the requirements for the degree

of

Doctor of Education

in

Education

MONTANA STATE UNIVERSITY  
Bozeman, Montana

March 2011

© COPYRIGHT

by

Florence Ray Gold

2011

All Rights Reserved

APPROVAL

of a dissertation submitted by

Florence Ray Gold

This dissertation has been read by each member of the dissertation committee and has been found to be satisfactory regarding content, English usage, format, citation, bibliographic style, and consistency and is ready for submission to the Division of Graduate Education.

Dr. Arthur W. Bangert

Approved for the Department of Education

Dr. Jayne Downey

Approved for The Graduate School

Dr. Carl A. Fox

## STATEMENT OF PERMISSION TO USE

In presenting this dissertation in partial fulfillment of the requirements for a doctoral degree at Montana State University, I agree that the Library shall make it available to borrowers under rules of the Library. I further agree that copying of this dissertation is allowable only for scholarly purposes, consistent with “fair use” as prescribed in the U.S. Copyright Law. Requests for extensive copying or reproduction of this dissertation should be referred to ProQuest Information and Learning, 300 North Zeeb Road, Ann Arbor, Michigan 48106, to whom I have granted “the exclusive right to reproduce and distribute my dissertation in and from microform along with the non-exclusive right to reproduce and distribute my abstract in any format in whole or in part.”

Florence Ray Gold

March 2011

DEDICATION

This dissertation is dedicated to my parents Gussie and David Vinikoor who instilled in me the love of learning and inspired me to reach for the stars.

## ACKNOWLEDGEMENTS

I don't know how I was able to accomplish this enormous task, but I do know that I could never have accomplished it without the help of others.

Dr. Arthur Bangert, my committee chair took the lead in helping me express my results in a professional manner. There are no words to express my gratefulness for all his input.

Dr. Elisabeth Swanson graciously advised and supported me throughout my graduate work. I can only strive to pay forward what she has given me.

Dr. Maurice Burke has not only given me incredible suggestions, but he is also has provided me with a model of teaching excellence.

Dr. Mary Leonard added depth of understanding to my work. She allowed me to look deeper into my work, which greatly improved the results.

Of course, I have many more educators, professors, students, friends, and family to thank. But foremost, I most thank Stacy Hale, of Johnson Space Center, for all of his ideas, support, and encouragement over the years of my involvement in HUNCH. Without his faith in me, none of this would exist today.

Others that helped significantly are Dr. Robert Peterson, my committee's graduate student representative, Julie Charron, who transcribed my digital recordings, Jennifer Miller, who formatted the dissertation, and Susan Sawyer, who edited the paper. Last, but not at all least, I have to thank my son Dan and husband Berril Gold. Dan was always willing to help me with all my computer and writing challenges. Berril was always willing to take over more of the household chores so that I could study or write.

## TABLE OF CONTENTS

1. INTRODUCTION .....	1
Background .....	1
The HUNCH Program .....	5
Statement of Problem.....	6
Purpose Statement.....	7
Research Questions .....	8
Significance of the Study .....	8
Definitions of Key Terms .....	9
Summary .....	14
2. LITERATURE REVIEW .....	15
Introduction.....	15
Learning Theories .....	19
Introduction.....	19
Motivation.....	20
Behaviorists.....	22
Humanists .....	23
Cognitive Theorists .....	25
Attribution Theory .....	26
Expectancy Theory .....	26
Social Cognitive Theory .....	28
Cognitive Apprenticeships.....	29
The Constructivists .....	31
Situated Learning.....	33
HUNCH Framework.....	35
Constructs That Influence Classroom Learning .....	42
Introduction.....	42
Enjoyment of Learning .....	44
Self-Concept of Ability.....	46
Influence of Anxiety on Learning.....	48
Anxiety in the Classroom.....	50
Anxiety and Learning Theories .....	51
Ability to Make Choices .....	53
Interest and Attitudes in Learning.....	57
Relevance of Learning .....	61
Relevance in the Science Classroom .....	63
Career Interest.....	65
National Efforts to Promote Interest in Science, Technology, Engineering, and Math Careers.....	67

## TABLE OF CONTENTS - CONTINUED

Introduction.....	67
Project Lead The Way .....	68
Physics First.....	69
NASA Programs .....	69
The HUNCH Program .....	70
NASA’s First Educational Goal.....	71
NASA’s Second Educational Goal .....	72
NASA’s Third Educational Goal.....	73
Relationship Between the HUNCH Program and the Seven Constructs Measured in the SIMSQ .....	75
Summary .....	79
<b>3. RESEARCH METHODOLOGY.....</b>	<b>81</b>
Introduction.....	81
Context of Study .....	82
Participants.....	82
Schools.....	83
Clear Creek High School .....	87
Huntsville Center for Technology .....	89
Cypress Woods High School .....	90
Cypress Ranch High School .....	91
Lincoln County High School .....	91
Laurel High School.....	92
Madison County Career Academy.....	93
Walker County Career and Technology School .....	93
Earnest Pruett Center for Technology (EPCOT) .....	94
Research Design.....	94
Data Collection Instruments .....	95
Introduction.....	95
Study Fidelity.....	96
Student Interests and Motivation in Science Questionnaire (SIMSQ) .....	97
Focus Groups .....	98
Stakeholder Interviews.....	99
Procedures.....	100
Data Analysis .....	103
Questionnaires.....	103
Analysis of Focus Groups and Interviews .....	103
Trustworthiness of Qualitative Research.....	104
Potential Limitations of the Study .....	107
Researcher Perspective .....	108



## TABLE OF CONTENTS - CONTINUED

Summary .....	110
4. RESULTS OF THIS STUDY .....	112
Introduction.....	112
Research Question 1: How do Students Who Participate in HUNCH Programs Perceive STEM Courses? .....	115
Introduction.....	115
Analysis of SIMSQ Results .....	116
Enjoyment of Science Classes .....	117
Self-Concept of Abilities in STEM HUNCH Classes .....	118
Lack of Anxiety in STEM HUNCH Classes .....	118
Ability to Make Choices in STEM HUNCH Classes .....	120
Interest in Science .....	121
Usefulness of Science Classes .....	122
Focus Group Interview Results.....	125
Emergent Themes .....	125
Enjoyment of STEM HUNCH Classes.....	125
Usefulness of STEM HUNCH Courses.....	128
Relevance of STEM HUNCH Classes.....	129
Self-Concept of Abilities in STEM HUNCH Classes .....	130
Student-Centered Learning in STEM HUNCH Classes .....	132
Individual Student Interview Results.....	134
Emergent Themes .....	135
Self-Concept of Abilities in Math and Science.....	135
Interests in STEM Coursework.....	138
Research Question 2: How do Students Who Participate in HUNCH Programs Perceive STEM Related Careers? .....	140
Introduction.....	140
SIMSQ Results.....	141
Interest in Science Careers.....	141
Focus Group Interview Results.....	142
Friends and Family .....	143
Exposure to STEM HUNCH Classes .....	144
Individual Student Interview Results.....	145
Family and Friends .....	146
Exposure to STEM HUNCH Classes .....	146
Teacher’s Survey .....	147
Research Question 3: What Learning Experiences do HUNCH Students Describe as Motivating Them Toward Pursuing Courses and Careers in STEM Areas? .....	148

## TABLE OF CONTENTS - CONTINUED

Introduction.....	148
Focus Groups Interview Results .....	149
Emergent Themes .....	149
The Hands-on Nature of the Learning Experience .....	149
The Challenging Nature of the Learning Experience .....	150
The Environment of the Learning Experience.....	152
The Lack of Anxiety of the Learning Experience .....	154
The Relevance of the Learning Experience .....	155
Individual Student Interview Results.....	156
Self-Concept of Ability in STEM Areas.....	157
Influence of Others on Decisions to Pursue STEM Careers.....	158
Summary of Focus Groups and Interview Results .....	160
Research Question 4: Do Students Who Have Two or Fewer Semesters in HUNCH Perceive STEM Courses and Careers Differently Than Students Who Have Participated in Three or More Semesters in HUNCH? .....	160
Introduction.....	160
SIMSQ Results.....	161
Enjoyment of Science Comparison for New and Experienced in HUNCH Groups .....	162
Self-Concept of Ability Comparison for New and Experienced in HUNCH Groups .....	164
Lack of Anxiety in HUNCH Classes Comparison for New and Experienced in HUNCH Groups.....	166
Ability to Make Choices in HUNCH Classes Comparison for New and Experienced in HUNCH groups .....	168
Interest in Science Comparison for New and Experienced in HUNCH Groups .....	170
Usefulness of Science Classes Comparison for New and Experienced in HUNCH Groups.....	173
Career Interest in Science Comparison for New and Experienced in HUNCH Groups .....	175
Summary of Results.....	177
Trustworthiness of Results.....	178
Triangulation of Quantitative and Qualitative Results from SIMSQ, Focus Groups, and Interviews .....	181
Introduction.....	181
Hands-on Learning.....	184
Enjoyment of Learning .....	184
Self-Concept of Abilities .....	185
Lack of Anxiety .....	185
Challenging Work.....	186

TABLE OF CONTENTS - CONTINUED

Student-Centered Environment.....	186
Relevance of Learning .....	187
Career Interest.....	188
The Influence of Others and Exposure to STEM Classes.....	188
Influence of Others .....	188
Exposure to STEM Classes.....	189
Summary.....	189
5. CONCLUSIONS.....	191
Introduction.....	191
Research Questions .....	192
Findings.....	193
Research Question 1: How do Students Who Participate in HUNCH Programs Perceive STEM HUNCH Courses and other STEM Courses? .....	193
Research Question 2: How do Students Who Participate in HUNCH Programs Perceive STEM Careers?.....	198
Research Question 3: What Learning Experiences do HUNCH Students Describe as Motivating Them Toward Pursuing Courses and Careers in STEM Areas?.....	204
Research Question 4: Do Students Who have Fewer Than Two Semesters in HUNCH Perceive STEM Courses and Careers Differently Than Students Who Have Participated in Three or More Semesters in HUNCH?..	209
Implications for Educators .....	211
Recommendations for Further Research.....	215
Conclusion .....	218
REFERENCES .....	220
APPENDICES .....	231
APPENDIX A:    NASA’s Educational Goals .....	232
APPENDIX B:    NASA Photographs of HUNCH Student Projects.....	234
APPENDIX C:    Structure of the HUNCH Program.....	237
APPENDIX D:    Mission Space: Research Design a Growth Chamber to Provide Food for Long Duration Missions. National Labs/HUNCH 2009-2010 .....	245
APPENDIX E:    Focus Group and Interview Questions.....	249
APPENDIX F:    Principal’s Consent Form for Participation in Human Research at Montana State University .....	253

TABLE OF CONTENTS - CONTINUED

APPENDIX G:	Subject Consent Form for Participation in Human Research at Montana State University and IRB Approval .....	255
APPENDIX H:	Student Interests and Motivation in Science Questionnaire .....	258
APPENDIX I:	HUNCH Schools for 2009-2010 School Year.....	262

## LIST OF TABLES

Table	Page
1. Learning Theories .....	21
2. Measuring Motivation to Succeed .....	28
3. Learning Theories and Their Related Constructs .....	43
4. Prevalent Motivational Constructs of STEM Programs .....	68
5. Summary of the HUNCH Program Structure .....	74
6. Courses That Incorporate HUNCH Activities .....	83
7. Listing of Schools in the HUNCH Program and the Number of Years That They Have Been Participating.....	86
8. Table of Specifications of Questionnaire: Seven Constructs of Student Motivation in Science Classes.....	98
9. HUNCH Schools and Project Information .....	114
10. Percent of Frequency Results for Enjoyment of Science Classes by HUNCH Students.....	117
11. Percent of Frequency Results for Self-Concept of Abilities in STEM HUNCH Classes by HUNCH Students.....	118
12. Percent of Frequency Results for Lack of Anxiety in STEM HUNCH Classes by HUNCH Students .....	119
13. Percent of Frequency Results for Ability to Make Choices in STEM HUNCH Classes by HUNCH Students .....	120

## LIST OF TABLES - CONTINUED

Table	Page
14. Percent of Frequency Results for Interest in Science by HUNCH Students.....	122
15. Percent of Frequency Results for Relevance of Science Classes by HUNCH Students.....	123
16. Percent of Frequency Results for Interest in Science Careers by HUNCH Students.....	142
17. Frequency of Students Participating in HUNCH Who Continued in STEM Courses Beyond High School .....	148
18. Descriptive Statistics and MANOVA Results for Comparison of HUNCH Experience by Semester for Enjoyment of Science Questions.....	163
19. Descriptive Statistics and MANOVA Results for Comparison of HUNCH Experience by Semester for Self-Concept of Abilities Questions...	166
20. Descriptive Statistics and MANOVA Results for Comparison of HUNCH Experience by Semester for Lack of Anxiety Questions.....	168
21. Descriptive Statistics and MANOVA Results for Comparison of HUNCH Experience by Semester for Questions Regarding the Ability to Make Choices .....	170
22. Descriptive Statistics and MANOVA Results for Comparison of HUNCH Experience by Semester for Interest in Science Questions .....	172
23. Descriptive Statistics and MANOVA Results for Comparison of HUNCH Experience by Semester for Usefulness of Science Class Questions.....	174
24. Descriptive Statistics and MANOVA Results for Comparison of HUNCH Experience by Semester for Career Interests in Science Questions.....	176
28. Summary of Triangulation of Results from SIMSQ, Focus Groups, and Interviews.....	182

LIST OF FIGURES

Figure	Page
1. Model of Interests Composed of Situational and Individual Interests.....	59

## ABSTRACT

In today's society of global economic competition, environmental concerns, and the race to explore outer space, the study of mathematics and science has reached the forefront of educational goals around the world. The gap between the number of STEM professionals in the United States and other countries is closing. To address this occurrence, private organizations, businesses, and government agencies are teaming up with schools to promote the study of Science, Technology, Engineering, and Mathematics (STEM) courses.

This research investigates the High School Students United with NASA to Create Hardware (HUNCH) program, an innovative school-based partnership between public schools and NASA, with the educational goal of motivating students to study and pursue careers in STEM areas. To evaluate the HUNCH program, this research takes a mixed-method approach that collects data quantitatively from an analysis of student responses on a *Student Interests and Motivation in Science Questionnaire* (SIMSQ) and qualitatively from an analysis of focus groups and individual student interviews of HUNCH participants.

This research answers the following questions:

- (1) How do students who participate in HUNCH programs perceive STEM HUNCH courses and other STEM courses?
- (2) How do students who participate in HUNCH programs perceive STEM related careers?
- (3) What learning experiences do HUNCH students describe as motivating them toward pursuing courses and careers in STEM areas?
- (4) Do students who have fewer than two semesters in HUNCH perceive STEM courses and careers differently than students who have participated in three or more semesters in HUNCH?

By investigating the HUNCH program, this research helps to identify the benefits of secondary schools teaming up with professional organizations, such as NASA, with the hope of encouraging and influencing the creation of new innovative school-based partnerships.



## CHAPTER ONE

## INTRODUCTION

Background

Since the cold war, the race to space, and the proliferation of innovative technologies, the United States has been particularly interested in motivating students to study STEM courses. However, during the past few decades, there exists a decline in the number of students studying STEM courses. For the United States to remain a leader in technological advances and creative innovations, it is critical to keep high-level scientific, technological, engineering, and mathematical jobs in the United States. The 2010 results from the National Science Board's Science and Engineering Indicators states, "Generally the trends indicate that while the United States continues to be the world leader in science and engineering, other countries, especially those in East Asia, are dramatically increasing their own investments in science and engineering and closing the gap" (National Science Board's Science and Engineering Indicators 2010 Release, 2010). Only by educating more American students in STEM fields today can the jobs of tomorrow be filled domestically.

Mathematics and science became a national priority during the late 1950s when the race to space began. In 1957, after Russia launched *Sputnik I*, President John F. Kennedy made it a national goal to land a man on the moon. New mathematics and science curricula followed in hopes of increasing student ability and interest in mathematics and science. The new curricula of the 1960s focused on the nature and logic

of scientific inquiry rather than scientific facts and theories (Park, 2006). The United States achieved its goal of landing a man on the moon, and history documents that the new curricula of the 1960s was successful in allowing America to lead the world in innovative technologies and space explorations.

In today's environment of teaching to tests, teachers are often leery of more time consuming innovative approaches. To combat this occurrence, innovative school-based programs, such as Project Lead the Way, Physics First, HUNCH and many other STEM programs are being implemented in order to increase authentic project based learning. Innovative school-based programs provide students with an approach to learning that utilizes problem-solving, applied knowledge, and creative thinking skills. Innovative school-based programs present situations to students in which the skills learned from textbooks and traditional classroom studies are applied to real-world situations. It is the goal of these programs to increase the diversity, quantity, and quality of students interested in STEM areas.

For example, if an innovative school-based program presented a student in machine class with the task of constructing a storage locker for NASA, the student would not only use his or her machining skills to build the locker, but also mathematics, science, and engineering design skills to meet the demanding standards set by NASA. In turn, the student would recognize the relevance of their traditional classroom knowledge by applying it to a real-world experience. One of the most appealing aspects of innovative school-based programs is that they often extend across subject areas, allowing for an integration of learning. This study's literature review briefly examines two innovative

school-based programs: Project Lead the Way (PLTW) and Physics First. However, this research takes an in-depth look at the HUNCH program.

Today, thousands of students are involved in new curricula designed by Project Lead the Way personnel. This program's goal is to bring relevant and challenging engineering curricula to students. PLTW's curricula, like the curricula of the 1960s, employ the application of science, technology, and mathematics to engage the students in creative, real-world engineering processes and projects. PLTW is present throughout most of the United States, and has been particularly successful in urban areas that have large schools (Chavanne, 2008).

While PLTW is the best-known and most widely employed middle and high school engineering program, other programs do exist. One of these programs is Physics First. Physics First seeks to change the horizontal and vertical alignment of secondary curricula in order to allow freshman students to enroll in physics courses. The rationale for this revision is that physics will provide freshman opportunities to apply their study of mathematics in real-world scenarios, helping to justify the logic of studying mathematics in a student's mind. A doctoral dissertation, written by Robert Goodman (2006) from Rutgers University, documents and evaluates the Physics First program. Goodman's dissertation investigated the effectiveness of Physics First by comparing the standardized science and mathematics test scores of New Jersey students enrolled in a Physics First curriculum to those in the traditional curriculum. Results from his research found that the 130 Physics First students scored well above average on the New Jersey State science and mathematics tests, while they earned average scores in other content areas such as

English or History. Although it is difficult to generalize results from this one study to other students across the United States, Goodman's findings offer a plausible argument for the positive effects of the Physics First program on student achievement. In addition, Goodman's findings substantiate the importance of students' understanding of the real-world applications of their learning.

Industry support plays a key role in bringing innovative school-based programs to students in grades Kindergarten through Grade 14. One of the more successful programs involve partnerships between corporations and science classes. Over 20,000 volunteers in the fields of science, technology, and engineering have participated in the *A World in Motion* (<http://www.awim.org/about/facts/>) program since 1990. This program receives support from corporations, foundations, volunteers and the Society of Automotive Engineers International. Students discover the applications of their scientific principles as they work as a team in an activities-based curriculum in their classrooms with volunteer mentors from their communities STEM workforce.

The Student Spaceflight Experiment Program (SSEP) sponsored by the National Center for Earth and Space Science Education (NCESSSE) in partnership with NanoRacks, LLC is dedicated to inspiring the next generation of scientists and engineers (<http://ncesse.org/>). The NCESSSE is a non-profit organization made up of a partnership of scientists and teachers whose goal is to inspire and engage students in science by exposing them to STEM professionals. The Student Spaceflight Experiment Program was started in June, 2010 and is designed to give students enrolled in grades 5 through 12 and at two-year community colleges an opportunity to design and fabricate an experiment to

fly on the last missions of the space shuttles. Presently, there are 16 student experiments selected to launch on onboard space shuttle Endeavor in April, 2011. The space shuttle Atlantis will also carry student experiments if it is commissioned to fly one last time. The SSEP is a new national initiative to inspire the next generation of scientists and engineers by involving them in authentic hands-on learning activities, with the support of STEM professionals and industry (<http://ssep.ncesse.org/>).

### The HUNCH Program

NASA has been involved with PLTW and an array of educational programs, activities, and competitions to stimulate student interest in science, technology, engineering, and mathematics areas. NASA's programs are for teachers and students of all ages, backgrounds, and locations. This research examines one of NASA's newer educational programs that began in the summer of 2003, called High School Students United with NASA to Create Hardware or HUNCH program.

The HUNCH program came into existence when NASA officials had a "hunch" that high school students could create needed training hardware for astronauts planning to work on the International Space Station (ISS). This program would require supplying schools with materials, tools, and oversight, while the schools would supply NASA with cost-effective training hardware. After the first year, an unexpected byproduct of having students build hardware was an increase in students' interest in science and space exploration as realized by the HUNCH teachers and engineers.

After the HUNCH program's successful first year in schools close to Johnson Space Center (JSC) and Marshall Space Flight Center (MSFC), NASA officials decided to test the possibility of establishing a HUNCH program in a school district located a great distance from any NASA presence. Laurel High School in Laurel, Montana, became NASA's selected school, because of its previous contact with NASA through its Laurel Aviation and Technology Week (LATW). LATW exposes students to an in-depth look at the latest technological and scientific innovations related to aviation (<http://www.laurel.k12.mt.us/19141043165033230/site/default.asp>)

### Statement of Problem

This research aims to examine the experiences of students participating in the HUNCH program, an innovative school-based program. A deeper understanding of effective learning experiences that occur in innovative school-based programs has the potential to help educators motivate students toward pursuing coursework and careers in STEM areas. Student participation in project-based, science curricula have been found to have positive influences on their interest in pursuing STEM coursework and STEM careers (e.g., Goodman, 2006; Walcerx, 2007). However, the research conducted with these types of STEM curricula have not investigated or identified the specific motivational constructs that have the most influence on student interest in STEM coursework and careers. It is the intention of this research to gain a better understanding of learning theory constructs that align with innovative school-based science learning experiences, which support student interest in the STEM areas. Finally, this research

reaches into the educational paradigm in which schools form partnerships with community businesses, agencies, and organizations. At a press conference on March 24, 2009, President Obama called for educational reform that would teach our children in a more effective manner. In a report by Horizon Research Inc. (Weiss, Pasley, Smith, Banilower, & Heck, 2003), further supports the need for reform in mathematics and science classrooms when results of observations by researchers who observed a sample of 364 mathematics and science lessons reported that only 15% of the K-12 lesson plans were rated high in quality. Furthermore, Weis et al. (2003), concluded, “Based on the observations conducted for the *Inside the Classroom* study, the nation is very far from the ideal of providing high quality mathematics and science education for all students (Weis et al., 2003, p. 104). This research study is intended to be the impetus needed to plant the seed of educational practices that allow for authentic classroom projects through partnerships with community professionals.

### Purpose Statement

The number of students choosing careers in engineering and scientific fields is diminishing in the United States (Osborne, Simon, & Collins, 2003; Kind, Jones, & Barmby, 2007). However, society’s need for professionals in these fields is increasing. The purpose of this mixed-method descriptive study is to depict how the learning experience from innovative school-based programs, specifically the HUNCH program, influences students’ motivation to study and pursue careers in STEM areas.

### Research Questions

- (1) How do students who participate in HUNCH programs perceive STEM HUNCH courses and other STEM courses?
- (2) How do students who participate in HUNCH programs perceive STEM related careers?
- (3) What learning experiences do HUNCH students describe as motivating them toward pursuing courses and careers in STEM areas?
- (4) Do students who have fewer than two semesters in HUNCH perceive STEM courses and careers differently than students who have participated in three or more semesters in HUNCH?

### Significance of the Study

The complexity of understanding the multi-faceted aspects of motivational behaviors presents a challenge to any research into classroom instructional practices. An extensive literature review revealed multiple studies that used quantitative data to evaluate secondary student motivation in science (Goodman, 2006; Hadre, Davis, & Sullivan, 2008; Hassan, 2008; Lau, 2002; Park, 2006; Teppo & Rannikmäe, 2004). A few more studies explored qualitative data by examining case studies of secondary students (Barnby, Kind, & Jones, 2008; Reiss, 2004). Only one study by Quihuis (2001) used both quantitative and qualitative data in evaluating motivational behavior in secondary students. Therefore, this research adds to the latter's limited research base by using a mixed-method approach.

Knowledge gained from this study aids schools, businesses, and agencies that want to expand or develop new innovative school-based programs to motivate students in



STEM areas. Sparse documentation exists about innovative school-based programs that promotes student enrollment in STEM courses. The significance of this study lies in the researcher's work in the following three educational arenas. First, the research determines what students perceive as the best motivating practices to encourage them to enroll in STEM courses. Second, the research explores the value of innovative school-based programs, such as HUNCH, on motivating students to pursue STEM careers. Third, the research examines the educational learning experiences of schools, businesses, and organizations teaming up to form innovative school-based programs.

Many educational terms can have different meanings in various contexts. The following definitions of key terms are essential for readers to understand the concepts that the author wants to convey when the specified term is applied in this study.

#### Definitions of Key Terms

1. *Ability to Make Choices* is the construct that involves student's empowerment in the decision-making processes of their learning (Hassan, 2008).
2. *Anxiety in Learning* is the construct where students feel stressed, concerned and less positive about their learning (Hassan, 2008).
3. *Attribution Theory* is used by cognitive theorists to quantify the degree of motivation for a particular behavior by three measurable dimensions, which are locus of control, stability and controllability (Weiner, 1986).
4. *Behaviorism* is a school of psychology that explains motivation toward a behavior by the external stimuli that a person associates with that behavior (Kolesnik, 1975).

5. *Career Interest* is the construct that measures the development of students' desire to pursue an occupation in a particular area (Hassan, 2008).
6. *Career and Technical Education* (CTE) also known as vocational education prepares students for applied trades as well as the engineering professions.
7. *Cognitivism* is a school of psychology that explains motivation toward a behavior by the way a person thinks about their experiences (Kolesnik, 1975).
8. *Communities of Practice* are groups of people of various abilities working together for a common purpose. It is made up of individuals who collectively learn from each other to accomplish a task (Lave & Wenger, 1991). Communities of learners are similar; however, their objective may be purely academic.
9. *Comprehensive High Schools* refers to a ninth to twelfth grade school where students take all of their courses within a single location.
10. *Constructivism* is a school of psychology whose followers believe that academic motivation is a direct result of students' experiences with their environment and others. Constructivists advocate that students are not passive learners but learn by creating their own knowledge from their experiences (Hickey, 1997).
11. *Enjoyment of Learning* is the construct that allows a student the feeling of happiness in learning. An important outcome of enjoyment of learning is the students' desire to pursue a career in the learning area (Hassan, 2008).
12. *Expectancy Theory* is used by cognitive theorists to measure motivation to succeed by quantifying three attributes, which are a person's expectancy to accomplish a task, a

person's incentive to accomplish a task, and a person's motive to accomplish a task (Atkinson, 1957).

13. *Extrinsic Motivation* involves the reasons for a person to accomplish a task, because of a reward or the avoidance of punishment (Sansone & Harackiewicz, 2000).

14. *Hands-on learning* involves engaging students in a physical level where they use their hands to actively learn from a task. This is in contrast to passive learning that involves listening or reading.

15. *Humanism* is a school of psychology that holds that a person's behavior is a product of how he or she perceives themselves and their experiences (Kolesnik, 1975).

16. *High School Students United with NASA to Create Hardware* (HUNCH) is an innovative school-based program designed to motivate students to study and pursue careers in STEM areas and assist NASA in training hardware for astronauts.

17. *Innovative school-based programs* are programs that are creating inventive classroom practices that lead to reform in instructional practices. For example, HUNCH is an innovative school-based program; because it forms a unique partnership between schools and NASA.

18. *Interests in Learning* is the construct that pertains to students' positive attitudes and involvement in learning (Hassan, 2008).

19. *Intrinsic Motivation* involves the reasons for a person to perform a task from an inner-perspective, which leads to interest and assimilation of the task (Ryan, Connell, & Grolnick, 1992)

20. *International Space Station* (ISS) is a large inhabited space satellite that was built in 1998 by sixteen nations of the world to promote space exploration and research.
21. *Johnson Space Center* (JSC) is NASA's lead headquarters for the ISS. It was established to provide facilities to design, develop, and test spacecraft.
22. *Laurel Aviation and Technology Week* (LATW) is an educational event that exposes students in Montana to the latest technologies and innovations in STEM areas.
23. *Motivation to learn* involves how students create their desires and goals that facilitate learning (Ryan et al., 1992).
24. *Learning Theories* are theories that link behaviors that involve learning with the constructs that bring about these behaviors (Driscoll, 2000).
25. *Marshall Space Flight Center* (MSFC) is headquarters to NASA's propulsion, engineering, and science payload facilities. In existence since 1960, it still follows the dreams of space exploration of one of its original scientists, Dr. Wernher von Braun (Hickam, 1998).
26. *National Aeronautics and Space Administration* (NASA) is the agency formed in 1958 to lead the United States in developing a space program and research.
27. *Programme for International Student Assessment* (PISA) is a standardized international student assessment for fifteen-year-old students, in science, mathematics, and reading (Lee, 2007).
28. *Project Lead The Way* (PLTW) is an educational program that allows high school and middle school students to participate in innovative engineering curricula (<http://www.pltw.org>).

29. *Relevance of Learning* is the construct that involves students' perception of the value of their learning to themselves and society (Hassan, 2008).
30. *Scholastic Aptitude Test (SAT)* is an examination in mathematics, critical reading, and writing for high school students applying for college admission.
31. *Self-Determination Theory (SDT)* is a psychological theory that examines the intrinsic motivation that develops by allowing for self-determined choices (Shih, 2008).
32. *Self-efficacy* is the perception a person has about his or her ability to successfully complete a given task (Lee, 2009).
33. *Self-concept of Ability* is the construct involving students' perception of their abilities to be successful in learning a particular subject (Lee, 2009).
34. *Student Interests and Motivation in Science Questionnaire (SIMSQ)* is the questionnaire developed by Hassan (2008) to measure seven constructs that influence student motivation in science.
35. *Social Cognitive Theory* is the psychological theory that a person's social interactions with his or her environment and others provides the basis for how a person thinks about his or her experiences (Driscoll, 2000).
36. *Science, Technology, Engineering, and Mathematics (STEM)* is the area of study which leads to technical skills needed in the fields of science, technology, engineering, and mathematics.
37. *Usefulness of learning* is the extent to which the learning is applied to other areas.

38. *Vocational High Schools/Career and Technical Centers* refers to high schools where students attend various vocational classes. The classes offered are of the vocational, agricultural, engineering, or technological nature.

39. *Zone of Proximal Development (ZPD)* is the term used by Vygotsky (1997) to indicate the region within which a student is able to persist and succeed in learning accompanied by support from a mentor.

### Summary

Utilizing a mixed-method approach, this study analyses the impact of NASA's HUNCH program on student motivation to study and pursue careers in STEM areas. By evaluating the HUNCH program's motivational practices this research will provide a better understanding of the factors involved in influencing students' interests in STEM areas. Ultimately, this study provides a research bases for implementing additional innovative school-based programs, proposed to increased numbers of American engineers and scientists.

## CHAPTER TWO

## LITERATURE REVIEW

Introduction

In an endeavor to motivate American students to study science, technology, engineering, and mathematics; government agencies and corporate businesses have collaborated to form innovative partnerships with educational institutions. This undertaking has come about because of the nation's need to meet the challenge of maintaining America's leadership role in innovative technologies (Association for Career and Technical Education, 2009). Renewed investments in educational practices that advance the interest and skills of students in science, technology, engineering, and mathematics are essential for securing the United States' economic future (Friedman, 2005).

Educators in the United States are facing a major challenge (referred to as the STEM Challenge) in their efforts to increase the quantity, quality, and diversity of students who are pursuing careers in STEM areas (Association for Career and Technical Education Issue Brief, 2009). From 1985 to 2005, the number of degrees in engineering or engineering technology fell dramatically. In 1985, there were 77,572 bachelor degrees in engineering and 53,700 associate degrees in engineering technology. In 2005, the numbers dropped to 66,133 bachelor degrees and 28,800 associate degrees (National Science Board, 2008). This is a 15 percent drop in engineering degrees and a 46 percent drop in engineering technology degrees (National Science Board, 2008).

Another dimension of the STEM Challenge is the lack of skills that students have in science and mathematics. The 2006 Programme for International Student Assessment (PISA) found that American students “performed much worse in science and math than students from other industrialized countries” (Association for Career and Technical Education, 2009, p. 2). Multilevel regression analysis using the Statistical Package for Social Sciences (SPSS) software was used to analyze 400,000 student responses from 30 different countries. Sixteen countries did better than American students in science and twenty-three countries did better in mathematics. High scoring countries were Finland, Canada, Japan, New Zealand, Hong Kong-China, Chinese Taipei, Estonia, Australia, the Netherlands, Korea, Germany, the United Kingdom, the Czech Republic, Switzerland, Austria, and Belgium (Organization for Economic Co-operation and Development, 2006). PISA’s assessment found that 18 percent of variance in American scores was due to socioeconomic status. This achievement gap is much larger than what was found in other countries whose students participated in PISA testing (Organization for Economic Co-operation and Development, 2006).

Achievement gaps are even more prevalent if ethnicity and gender are considered. On the Scholastic Aptitude Test (SAT) mathematics sections, African American and Hispanic students’ scores are much lower than Asian-American and white students’ scores. Moreover, female scores are consistently lower than males on the mathematics SAT assessments (Corbett, Hill, & St. Rose, 2008).

In order to build interest and improve achievement in STEM areas and careers innovative programs are seeking to expose underrepresented populations to STEM fields.



The HUNCH program is a good example of this. It initially targeted vocational technical schools and courses where students do not normally plan on going to college or working for NASA (Thomas, Robinson, Tate, & Thumm, 2006). A recent survey by Massachusetts Institute of Technology (MIT) found that two-thirds of high school students indicated that they do not know anyone who works in STEM areas, and the students did not know what people's work entails in these fields (Massachusetts Institute of Technology, 2009). To remedy a lack of student understanding of STEM careers, programs have developed that are sponsored by organizations and agencies that are providing mentors, internships, and support services in order to expose more students to STEM careers. Career and technical education (CTE) programs have also developed that are linking students with professionals in STEM areas in order to incorporate higher-level mathematics and science skills into technical courses (Association for Career and Technical Education, 2009). These programs are necessary for attracting a greater diversity of students as well as improving their skill levels.

The following literature review describes the constructs that are hypothesized to promote learning that occurs within innovative school-based STEM related programs. The literature review links the constructs of learning theories with the motivational practices of the HUNCH program.

Seven constructs listed in Table 3 are measured using the Student Interests in Science and Motivation Questionnaire (SIMSQ) developed by Hassan (2008). Hassan chose these seven constructs after an extensive literature search. His search included several questionnaires that were developed to quantify student attitudes toward science,

such as the Test of Science-related Attitudes (ToRSA). The ToRSA questionnaire was shown to be 'highly' reliable and some of the questions in it, along with other reliable questionnaires, were included in the initial 60 questions on SIMSQ (Hassan, 2008). Hassan's questionnaire was designed to operationalize the seven constructs that his literature review identified as the most relevant to students' interest and motivation in science. Hassan's seven constructs as a measure of student perceptions of interest in science are well supported in the literature (Barnby et al., 2008; Hadre et al., 2008; Reiss, 2004; Shun Lau, 2002; Quihuis, 2001). For example, Hadre, Davis, and Sullivan's 2008 research on teachers' perceptions of student interests includes all seven constructs as significant motivational constructs. The seven constructs or classroom practices operationalized by Hassan (2008) are included within the frameworks of the four major views of learning: behavioral, humanistic, cognitive, and constructivism. Each group's theorists believe in various reasons for academic motivation. The behaviorists believe that academic motivation is the result of external stimuli. The humanists consider how a student views his experiences to be the most important motivational construct. The cognitive theorists believe that how students think about their learning and themselves are the most important contributors to academic motivation. The constructivists believe that academic motivation is a direct result of students' experiences with their environment and others. While all are different, all four theories play important roles in today's educational practices.

This literature review will start by introducing four basic learning theories and examining how they relate to the set of constructs that are measured in the *Student*

*Interests and Motivation in Science Questionnaire*. The four learning theories that are examined were chosen for two main reasons. First, the learning theories are the most prominent and widely accepted theories in academia. Second, the constructs in the SIMSQ relate well to these theories' constructs of motivation to learn.

## Learning Theories

### Introduction

It is almost impossible for one theory to account for all of the constructs that encompass the complex and multifaceted concept of motivation to learn. Whether it is aptitude in a subject matter or inspiration from a family member, students receive their motivation from various sources. Motivation to learn not only involves how educational practices can facilitate learning, but also how students' inner thoughts and experiences facilitate learning (Ryan et al., 1992). This research will consider four learning theories that have withstood the test of time: behavioral, humanistic, cognitive, and constructivism, which closely examine both the educational practices and the beliefs of students that lead to learning. The theories discussed in this section all have similarities and differences. In Table 1 the learning theories and theorists are categorized for the ease of explanation in this literature review, according to their principle assumptions. However, the underlying question that all learning theorists strive to answer is, "What can educators do to motivate student learning?" Without the motivation to learn, there is no learning. New theories typically develop because of the previous theories' inability to account for an aspect of learning.

## Motivation

Over the past decade, the term motivation has taken on various meanings in educational research. The definition of motivational research during the twentieth century as defined by *Webster's New Twentieth Century Unabridged Dictionary* (1972) was, "A systematic and scientific analysis of the forces influencing people so as to control the making of their decisions" (Webster, 1972, p.1173). The above definition pertains to examining external forces that cause behaviors. An internal perspective of motivation is given by Ryan, Connell, and Grolnick (1992) in which they define motivation to learn from an "inner-perspective" – "what it is inside the learner that leads her to focus on something, take interest, and assimilate it" (Ryan et al., 1992, p.167). This definition pertains to intrinsic forces that cause behaviors. Motivation to learn in this instance comes from within students. Learning occurs when students are processing new information into their schema of knowledge.

How one defines motivation determines the approach one takes toward the study of motivation. This literature review's definition of motivation uses both the external environmental forces such as grades, rewards, punishments, social pressure, etc. and the intrinsic personal characteristics of students such as drives, needs, interests, curiosity, and cognitive thinking. These internal and external forces, when combined, control behaviors to learn (Hidi, 2000).

This research examines motivation to learn in general and motivation to learn science, technology, engineering, and mathematics in particular. Motivation to learn is a required first step in achieving academic success, but it is not the only step. There are

three noticeable steps toward academic success - The first being motivation to learn or engage in an activity, the second being acquisitions of appropriate skills, and the third being motivation to persist and accomplish the task successfully. However, it is motivation to learn that this literature review presents, because the purpose of this literature review is to explore learning theories' constructs and their relationship with motivation to learn, particularly in STEM areas. This literature review is germane because motivation to learn is the first and directly applicable step to academic success.

The literature review examines each of the learning theories and relates them to motivational practices that promote classroom learning. A summary of these learning theories are presented in Table 1. These theories are not unique to science but are applied to learning in general.

Table 1. Learning Theories.

	Behavioral	Humanistic	Cognitive	Constructivism
Source of Motivation	Extrinsic	Intrinsic	Intrinsic	Intrinsic
Important Concepts	Conditioning of behaviors due to positive and negative reinforcement	Hierarchy of Needs ending in self-actualization ARCS Model	Attribution Expectancy Theory Social Cognitive learning Theory	Learning through experiences Situating Learning
Key Theorists	Watson, Pavlov, Skinner	Maslow Keller	Weiner, Atkinson, Bandura,  Collins, Brown, & Holum	Piaget, Vygotsky, Lave & Wenger

## Behaviorists

Behaviorists believe that conditioning from external stimuli controls behaviors. Behavioral learning theory emerged in the 1920's with experiments performed by scientists like John B. Watson and Ivan Pavlov. According to the behaviorist paradigm, positive reinforcement is the strengthening of a behavior by the use of rewards or responses, which increase the likelihood that the behavior will occur again. Behaviorists believe that a person's behaviors, feelings, emotions, and perceptions are simply a result of conditioning by reinforcements, which have taken place during the person's lifetime.

The behavioral theory infiltrated educational practices by advocating the application of positive reinforcement to motivate students to learn. Today's classrooms all use forms of extrinsic motivational practices. The use of tokens, stars, grades, praise, certificates, etc. are all forms of positive reinforcements that promote positive behaviors in classrooms.

The question arises if, in today's classrooms, we want to motivate students to learn by extrinsic motivational rewards; or alternatively, do we desire students to become intrinsically motivated so they have a greater potential to grow to be lifelong learners? Friedman (2005) advocates for educators to instill the love of learning into students, which requires intrinsic motivation to learn. The move toward intrinsic motivation to learn begins with both students and society valuing education to notable importance (Ryan et al., 1992).

## Humanists

The humanists came into existence because they did not believe that behaviorists can adequately describe the motivational forces behind a person's behavior (Deci & Ryan, 1992). According to humanists, motivation to learn is not adequately explained simply in terms of external stimuli or rewards. Humanists believe that motivation to learn is intrinsically motivated by a person's inner perceptions of their experiences with the world (Deci & Ryan, 1992). For example, being a finalist in a school's spelling bee may be perceived as successful to one contestant, but not to another who views success in terms of only winning the contest. Humanists believe that how a person perceives an event is just as important as what actually occurs during that event (Maslow, 1943).

The humanist, Abraham Maslow, developed the concept of self-actualization and a hierarchy of needs. He believed that the starting point for learning was a person's physiological needs or drives (Maslow, 1943). If a person's physiological needs such as safety, love, and esteem are met, then the person will seek self-actualization. Self-actualization is the need for a person to be all that he or she can be. Maslow (1943) states it this way, "What a man *can* be, he *must* be" (p.382), as he strives to reach self-actualization. Self-actualization is the realization of a person's full potential as a human being. When a person reaches self-actualization, they become morally and intellectually motivated to behave in the most humane manner possible (Maslow, 1943).

Another prominent humanist is John Keller, who originated the ARCS acronym to represent four major constructs for motivation of learning: Attention, Relevance,

Confidence, and Satisfaction (Keller, 2000). Below is a description for each component of the ARCS construct.

*Attention*, according to Keller (2000), comes about by arousing students' curiosity. The use of surprise or challenges that produce students' thinking in a creative and challenging way stimulates students' attention. Students enjoy a challenge and learning takes place when students' interests and curiosity are stimulated (Keller, 2000).

*Relevance* increases motivation to learn by adding an authentic purpose or value to learning. Keller (2000) suggests that students learn best when they are learning material that applies their learning to present and future goals. Keller states that students need the freedom of choice in order to choose areas that are specifically relevant to them.

*Confidence* is essential for students to persist and master their learning. If a task is challenging but achievable, then the task builds self-confidence and a feeling of accomplishment. Students should recognize that their efforts lead to the successful completion of their projects (Stipek, 2002).

*Satisfaction*, according to Keller (2000), implies that learning must be rewarding. The task must lead to a feeling of accomplishment and have real value to the student and or society. Satisfaction increases the likely hood that students will want to pursue careers in areas of interest (Keller, 2000).

The four components of motivation in the ARCS model align themselves well with the seven constructs in this research in the following manner:

**Attention-** implies *enjoyment* and *interest* in science,

**Relevance-** implies *usefulness* of science, and the *ability to make choices*.



Confidence- implies *self-concept of ability* and *lack of anxiety*,

Satisfaction- implies *career interest* in science

### Cognitive Theorists

The following section explains three prominent theories of cognitive theorists.

These three theories were chosen because they directly relate to motivation to learn. The first is attribution theory, which measures the degree of intensity of motivation to perform a particular task. The second is expectancy theory, which measures the degree of motivation to succeed at a particular task. The third is social cognitive theory, which expands cognitive theory beyond the “thinking” involved in learning to include the social interactions that influence learning. Social cognitive theory also encompasses cognitive apprenticeship theory of Collins, Brown, and Holum.

Cognitive theorists believe that rewards or punishments do not influence human behavior as much as how one thinks about these reinforcements. While the behaviorists believe that a habit or behavior is the consequence of repeated stimuli, the cognitive theorists believe that the controlling component of behavior is the reasons a person attaches to the causes of a stimuli and not the stimuli itself.

Cognitive theorists believe motivation to learn comes from the internal cognition of a person’s belief system (do they think they are smart in math, do they have a goal to become an astronaut, etc.), while humanists believe that motivation to learn comes from a person’s perception of an external stimuli (is the stimuli interesting, is the stimuli enjoyable, etc.). Both cognitive theorists and humanists believe that external stimuli

themselves are not the controlling factor for motivation to learn, as the behaviorists believe.

Attribution Theory. Cognitive theorists apply attribution theory to learning using the framework of Bernard Weiner. Weiner suggests that the driving force in attribution theory is the desire for students to understand the “why” of an event (Ames & Ames, 1984). For example, a student may want to know why he failed an exam. Usually, the cognitive thinking about “why” involves negative occurrences such as the asking of why he or she received a bad grade (Ames & Ames, 1984).

In order to answer “why” questions, attribution theory considers three dimensions: locus of control, stability, and controllability. Cognitive theorists believe that the three dimensions of attribution theory quantify the degree or intensity of motivation resulting in a specific behavior. The best combination for motivating students after a successful event is that the students believe that they have an internal locus of control that is controllable and is either stable or unstable. For example, if a student believes his good grade on a mathematics test is due to his effort (an internal locus of control) that is controllable, then he would be motivated to continue to exert effort.

Expectancy Theory. The second theory of the cognitive approach to motivation is expectancy theory. In 1957, John Atkinson wrote an article in *Psychological Review* that explains classic expectancy theory as a method to measure motivation to succeed by quantifying three key attributes. The attributes Atkinson seeks to quantify in order to measure motivation to succeed are a person’s expectancy to accomplish the task, P

(success), a person's incentive to accomplish the task,  $I$  (success), and a person's motive to accomplish the task,  $M$  (success). The resulting equation is motivation to succeed =  $P$  (success)  $\times$   $I$  (success)  $\times$   $M$  (success). The difference between a person's incentive to accomplish a task and a person's motive is that incentive involves what the person is going to get for accomplishing the task either physically or mentally, while motive is the purpose of the task.

The usefulness of Atkinson's equation to studying motivation is that a person can examine the influence of each variable on motivation. For example, Table 2 indicates that when a person's motive (disposition for success) is constant at one, then the largest motivating value occurs with an expectancy value of  $P$  equal to 0.5. Any higher or lower expectancy values cause a decrease in motivation for success. Atkinson's equations verify Vygotsky's work as far as both men advocate that learning occurs when students are given tasks that are neither too difficult nor too easy for them to accomplish. Vygotsky calls this occurrence a task that falls within the students' Zone of Proximal Development.

Table 2. Measuring Motivation to Succeed

Motivation to Succeed =				
M x P x I				
	M (Success)	P (Success)	I (Success)	Equals Motivation to succeed
Task A	1	.10	.90	.09
Task B	1	.20	.80	.16
Task C	1	.30	.70	.21
Task D	1	.40	.60	.24
Task E	1	.50	.50	.25
Task F	1	.60	.40	.24
Task G	1	.70	.30	.21
Task H	1	.80	.20	.16
Task I	1	.90	.10	.09

Note. Adapted from “Motivational Determinants of Risk-Taking Behavior,” by J.W. Atkinson, 1957, *Psychological Review*, 64, p.362).

Social Cognitive Theory. One of the leading cognitive theorists is Albert Bandura, whose work on the influence of society in learning created the subgroup of social cognitive theorists. Bandura’s work promotes three assumptions of learning. The first assumption is that learning occurs from the reciprocal interactions between behavioral actions, cognitive thinking, and environmental events. The second assumption is that self-efficacy, defined as the judgment of one’s own abilities in a given situation, has a dramatic effect on learning, achievement, motivation, and persistence (Bandura, 1997). The third assumption is that enactive learning, which is learning by doing, and

vicarious learning, which is learning by observing others, promotes knowledge (Bandura, 1997; Bandura, 1989; Pintrich & Schunk, 2002).

Social cognitive theorists and Bandura in particular are interested in the influence of self-efficacy on learning. Self-efficacy is task specific and it develops from a person's positive experiences in successfully achieving the task. Bandura suggests that the level of perceived self-efficacy is directly proportional to the level of a person's motivation to act and persist on any given task (Bandura, 1994). According to Bandura, self-efficacy contributes significantly to motivation, task persistence, and career choices (Bandura, 1997; Bandura, 1989; Pintrich & Schunk, 2002). Students who have high self-efficacy are more likely to attempt and persist in tasks. When students persist on tasks, their skills and knowledge continually increase. Students with a low self-efficacy resulting in a fear of failure may not even attempt some tasks; thus their knowledge and skills remain stagnant (Bandura, 1997; Bandura, 1989; Pintrich & Schunk, 2002).

The following section details the instructional practices of cognitive apprenticeships, which are a branch of cognitive learning theory. Cognitive apprenticeship theorists propose that the best "thinking" about learning occurs in an environment where students have mentors to learn from and emulate.

Cognitive Apprenticeships. "Thinking" about your learning is an important concept to all cognitive theorists. However, the work of cognitive apprenticeship theorists takes a giant leap to link schooling with "thinking." Much of the learning in school often involves "invisible thinking" (Collins et al., 1991). "Invisible thinking" is the ability to carry out a task, without reflecting or verbalizing the thinking involved to carry out this

task. The work of Collins, Brown, and Holum on cognitive apprenticeships attempts to make school “thinking” visible. In order to make school “thinking” visible, Collins, et al. (1991) have students and teachers often exchanging roles. In order for a student to teach a skill, they must be able to verbalize the processes required for accomplishing the skill. This verbalization of the thinking process is what makes school “thinking” visible. Collins et al. (1991) use reciprocal teaching, the practice of students instructing others, as an example of making school “thinking” visible.

Cognitive apprenticeship is an instructional paradigm that works best in classrooms that employ communities of learners that are working on complex tasks. It promotes a learning environment in which students are actively engaged in tasks that continually increase in complexity and diversity. This allows students to learn how to use their learning at the given task as well as how to teach others (Collins et al., 1991).

The following are four main aspects of cognitive apprenticeships:

1. Modeling provided by mentors to allow students to receive as much help as needed.
2. Support provided by mentors to assist the students to successfully complete the tasks.
3. Fading of mentors’ guidance as the skills of students advance.
4. Coaching provided by mentors throughout the entire learning process.

When classrooms provide mentors that engage students in their specialization, unique opportunities develop that allow students to learn by observing peers at different stages of expertise (Collins et al., 1991). The existence of variability of student expertise allows students to take on dual roles as learners and mentors. This is an important aspect of

cognitive apprenticeships, because it promotes student thinking and reflecting on their own learning, along with requiring them to use their knowledge to help others.

### The Constructivists

The following section presents the work of Piaget and Vygotsky, two leading constructivists who often agree and sometimes disagree with each other. The final part of this section presents the work of Jean Lave and Etienne Wenger, who promote a constructivist's approach to learning, and give special importance to the environment where the learning activity is situated.

Constructivists advocate that students are not passive learners but learn by creating their own knowledge from their experiences. Constructivists believe that classroom activities need to instill positive thinking about students' abilities (Hickey, 1997). Jean Piaget (1896-1980) was a pioneering constructivist. Piaget believed that people's experiences allow for the acquisition of knowledge into their preexisting schema (Piaget, 1971). Therefore, students are not blank slates that teachers must fill up with knowledge, but students have schemas of knowledge that new learning changes, adds to, or deletes. Piaget's work suggests that students' prior knowledge and experiences allow each to construct his or her own meaning of knowledge. His work explains how students are motivated to modify their knowledge as they mature. Piaget believed that students' actions were not randomly motivated but were due to innate maturation of children's physiology (Piaget, 1971).

During the past few decades, alternative perspectives to Piaget's views have contributed to learning theory. Some constructivists believe that motivation to learn is not

based on developmental age-appropriate stages; but motivation to learn is based on a child's experiences (Driscoll, 2000). The question arises if exposing children to higher-level thinking experiences at younger ages will allow children to reach the formal operational stage at earlier ages.

Social cultural constructivists, such as Vygotsky, believed that learning is dependent upon the type of interpersonal relationships that are established when individuals collaborate with one another. Motivation for learning occurs when schools support communities of learners that value education. Vygotsky (1997) advocated for schools to facilitate communities of learners, in which some of its members are more knowledgeable or talented than others. It is motivational to children when they have role models whom they aspire to be like.

Suzuki (1983) started a very successful school of violin instruction in part based on Vygotsky's theory of communities of learners. Violin students of all ages have group lessons and perform together at concerts. The less advanced students are motivated to work hard so that they can perform the beautiful concertos played by the advanced students.

Vygotsky's (1997) work, though written in the early 1900's behind Russia's iron curtain, contained many of the current ideas of the humanists, cognitive theorists, and constructivists. Vygotsky believed that education must meet students' individual needs, interests, and abilities. He further suggested in his writings that teachers should act as guides and monitors in order to maintain students learning in their Zone of Proximal Development (ZPD) (Alexander & Winnie, 2006). The ZPD is similar to Atkinson's



expectancy theory, where motivation to learn is optimal when the probability to succeed at a task is 50%, indicating the middle range of task difficulty. Vygotsky advocated that teachers should use “scaffolding” to keep students persisting at a task. Scaffolding, in this case, is defined as a teacher or mentor providing just enough assistance for a student to successfully complete the task (Alexander & Winnie, 2006). Vygotsky’s (1997) social cultural approach to learning requires students to be active members of communities of learners. It is through discussions, enactive, and vicarious learning that students become more knowledgeable and motivated to learn. Vygotsky (1997) wrote how students actively learn from social interactions, such as classroom discussions, and hands-on projects. The role of the teacher in the classroom is to provide students with rich experiences that are necessary for students’ knowledge to grow.

The ideas of Piaget and Vygotsky differ, even though they are both constructivists. Motivation to learn varies as a child matures; and learning follows developmental stages, according to Piaget. However, motivation to learn is inspired by a child’s experiences and precedes a child’s development, according to Vygotsky. The importance of a child’s experiences became the main focus of learning theorists in 1980s and 1990s who promoted situated learning. The following section details some of the instructional practices of situated learning theorists.

### Situated Learning

In 1991, Lave and Wenger wrote a book called *Situated Learning Legitimate Peripheral Participation* (The Press Syndicate of The University of Cambridge). This book presents an instructional paradigm that is based on student participation in

communities of practice within classroom settings. *Community of Practice* refers to a learning environment in which participants of various abilities and expertise actively engage in using real-world tools to complete complex tasks (Collins et al., 1991). The purpose of this instructional paradigm is to promote effective use of knowledge, so that skills learned in school can be transferred to real-world problems (Lave & Wenger, 1991). Situated learning theorists promote the idea that to be able to transfer knowledge; students need to be exposed to more than abstract concepts. Students need to learn concepts that are embodied in authentic activities, with teachers or professionals acting as mentors as they apply their knowledge (Brown, Collins, & Duguid, 1989).

Situated learning theorists believe that all learning is situated. Wineburg (1989) writes, “Knowledge is not free-floating but situated in activity.” Wineburg continues by writing that “School subjects have strayed too far from their disciplinary subjects” (Wineburg, 1989, p. 2). Each and every classroom has its own environment; however, the usual classroom environment involves the practices of memorization and regurgitation of factual concepts learned simply by listening or reading. If the “environment” of learning is an essential component of instruction, as Lave, Weiner, and their followers strongly believe, then teaching needs to incorporate authentic activities into classroom practices. The problem is that classroom environments habitually do not contain authentic activities where individual heuristics, intuitive reasoning, discovery of strategies, and decision making are salient (Brown et al., 1989).

The following section discusses a framework of learning that is prevalent in HUNCH classrooms. The framework is based on several of the constructs of the

previously mentioned learning theories, but is best described by situated learning theory.

The framework consists of seven principles, each of which will be examined in detail.

### HUNCH Framework

The classroom framework for HUNCH uses principles from all of the previously mentioned learning theories. The situated learning instructional paradigm is salient in HUNCH classrooms, as the HUNCH classroom is truly a community in which teachers, mentors, and students are all engaged in complex, authentic tasks. The following framework consists of seven principles that best characterize the HUNCH classroom.

1. Successful students are those that can apply their knowledge and skills across disciplines, exhibiting an ease of transferability.
2. Learning is dependent on students' innate curiosity and interests rather than their instruction in school.
3. Intelligence is largely dependent on a normal child's real-world experiences along with his or her innate abilities.
4. The mode of learning must change concurrently with the technology of the day.
5. Valid learning cannot be formally measured, but rather measured by the students' higher order thinking skills when applied to real-world problems.
6. Instruction is best when the apprenticeship type of learning is not seen as frivolous or ineffective, but rather as an essential part of making learning relevant.
7. Learning is a consequence of thinking, not memorization.

The following section lists the seven principles that characterize the HUNCH classroom and links them to learning theories.

1. *Successful students are those who can apply their knowledge and skills across disciplines, exhibiting an ease of transferability.* The ability to transfer knowledge

is a consequence of situated learning (Collins et al., 1991). This occurs because students have the opportunities to observe various ways to solve problems or accomplish a task by various members of a community of practice. Students learn that their knowledge to solve one problem can often be applied to an entirely different context. The application of knowledge in this way requires deep understanding, which is fostered in classrooms where students have ample time and opportunities to resolve problems utilizing their own abilities. Teaching for understanding, which allows for the transferability of skills, comes about by problem-solving activities, which are salient in communities of practice (Perkins, 2009).

2. *Learning is dependent on students' innate curiosity and interests, rather than their instruction in school.* The importance of student interest in learning is most relevant to the humanists. They believed that students are naturally curious and that each student has their own interests and abilities that should be cultivated. Keller's ARCS model emphasizes the principle that in order to engage a student in learning, his or her attention must first be obtained through interesting tasks that spark their curiosity (Keller, 2000). Within communities of practice, tasks are varied and challenging enough to attract students' attention.
3. *Intelligence is largely dependent on a normal child's real-world experiences along with their innate abilities.* Vygotsky (1986) advocates that learning develops through the sociocultural experiences of a child. Situated learning theory

also promotes learning through experience. These theorists believe that learning occurs best through experience (Lave & Wenger, 1991).

This principle also raises the question of nature versus nurture. It is best to view this question by realizing that nature and nurture are not in competition with each other, but rather form a synergy that allows for growth of intelligence beyond what either the innate abilities or experiences of the child could do alone.

4. *The mode of learning must change concurrently with the technology of the day.*

This principle involves “change,” which people generally resist. However, it is today’s students who are forcing “change” in the classroom. No longer does learning occur at the rate of “chalk and talk” (Jukes, 2003). Teachers are complaining that students are bored and students are complaining that teachers are boring. This may be due to a digital divide between students and some teachers (Jukes, 2003). Schools no longer are revered as the only place for learning.

Learning can easily take place in homes as students use the internet to connect with experts from all areas of study. There exists a digital divide between digital native learners and digital immigrants, who have had to migrate to digital technologies (Jukes, 2003). In the paper “Learning in the New digital Landscape” by Jukes, he list nine concepts that separate the digital natives (students) from the digital immigrants (some teachers). Three of these concepts directly apply to this fourth principle. They are as follows:

- Native learners prefer to interact/network simultaneously with many others.

- Many teachers prefer students to work independently rather than network and interact.
- Native learners prefer to learn “just-in-time” while many teachers prefer to teach “just-in-case” (it’s on the exam).
- Native learners prefer learning that is relevant, instantly useful and fun, while many teachers prefer to teach to the curriculum guide and standardized tests (Jukes, 2003).

More recently, Collins and Halverson (2009) have written a book titled *Rethinking Education in the Age of Technology* (Teachers College Press) to address the issue of technology and how it affects education. The authors realize that no longer should schooling be confined within the walls of a school.

5. *Valid learning cannot be formally measured, but rather measured by the students’ higher order thinking skills when applied to real-world problems.* This principle lays a new foundation for accountability. Standardized testing is rapidly gaining clout in today’s proposal by President Obama’s “Race to the Top” and “No Child Left Behind.” However, the needs of today’s society require that learning no longer involve large amounts of the acquisition of facts and figures that are incorporated into textbooks. Today’s students must learn how to work with others, to think creatively, and to transfer skills across subject areas so that they can resolve future issues that have not even become a problem yet.

Even as far back as the early 1900’s, John Dewey (1938) realized that the aim of education is not simply to pass on past knowledge. This approach would not adequately be able to meet the needs of future generations in the 1930s or 2010. Dewey laid the ground work for progressive education that would be able to

change with the times. American education needs to be able to change with the times.

American schools desperately need to produce the quality, quantity, and diversity of students who are competitive in the global market and resourceful enough to solve global problems. Linda Darling-Hammond recently wrote a book about the necessary changes required in order to build a better educational system for all. In her book *The Flat World and Education: How America's Commitment to Equity Will Determine Our Future* (Teachers College Press 2010), she has a chapter called "Rote Learning to Thinking Schools." In this chapter, she points out that the highly successful schools in Singapore have changed their admission requirements from standardized tests to assessments that involve thinking outside of the box and risk-taking (Darling-Hammond, 2010). The Singapore schools' plans involve systematically developing intellectual curiosity and project work (Darling-Hammond, 2010). As other nations move away from rote learning and forward to learning that requires higher order thinking skills, America must follow in order to remain a leader in innovation.

6. *Learning occurs best when the apprenticeship type of learning is not seen as frivolous or ineffective, but rather an essential part of making learning relevant.*

Common sense dictates that if a student is not interested in learning, then no overhaul of instructional practices will succeed in improving education.

Therefore, the goal for educators is to create an environment where students are intrinsically motivated to learn and accomplish a task. From ancient times, skills

and knowledge were passed on from generation to generation by young people working alongside their elders. Today, this is known as apprenticeships. Many trades are still learned in this fashion.

In the 1980's to early 1990's, cognitive apprenticeships and situated learning received much attention from educational theorists. Since then, its prominence has declined. However, students have always learned best by experiences; and to bring back educational experiences that involve communities of practice is raising the bar, not lowering it, for education. John Seely Brown, the head of Xerox's Palo Alto Research Center, was one of the 1980's advocates of cognitive apprenticeships. He advocates for learning to involve, allowing students the time and environment in which they can try things out and synthesize information under the guidance of mentors on real-world tasks (Brown et al., 1989). Apprenticeship-type learning according to Brown and his followers is a worthwhile activity and certainly not frivolous.

7. *Learning is a consequence of thinking, not memorization.* Knowledge is growing exponentially. It is impossible for any human brain to keep up with the information explosion, and more importantly it is not necessary. In the 21<sup>st</sup> century, learning is constantly involving to require less memorization and to require more of the ability to access information. The successful student knows how to use modern tools to do research. The successful student knows how to use the resources available in a creative way to problem-solve. The successful student can think outside of the box to develop an innovative process to complete a task



(Darling-Hammond, 2010). Situated learning is important because it fosters the above-mentioned skills (Palincsar, 1989). According to Palincsar, situated learning places an emphasis on the process of learning, as it relates to life tasks, and not memorization.

In conclusion, the essence of the HUNCH framework is that students learn best through experiences. This has always been true, but it is more important today than ever, because today our main goal is to create life-long learners with enthusiasm for learning, with innovative thinking and reasoning skills. Tomorrow's work force will have jobs that do not even exist today. Future workers will face increasing globalization and international communities of practice that will include people from around the globe. If we want to prepare today's students for their future jobs, then an emphasis on learning within communities of practice must lead the way.

The HUNCH framework draws on the perspectives of motivation from all four learning theories: behaviorists, humanists, cognitive theorists and constructivists. While all have similarities and differences, there is room for the overlapping of concepts as one theory is not mutually exclusive of the next. The behaviorists suggest that external stimuli control behaviors. The humanists suggest that how one perceives the external stimuli control behaviors. The cognitive theorists are concerned with how one thinks about his experiences. Constructivists suggest that learning is constructed from experiences. All four theories have points of intersection, and it is important to understand this in order to appreciate how innovative school-based programs apply these learning theories to classroom practices.

The following section is a literature review of the constructs of the learning theories that have been found to be most relevant to the motivation of learning in science and are incorporated into the learning theories previously discussed. The seven constructs were chosen because they were operationalized by Hassan (2008) in his *Student Interests and Motivation Science Questionnaire*, which is used to collect quantitative data in this research. The following list is of the seven constructs that are researched in this section: enjoyment of science, self-concept of ability in science, lack of anxiety in science, ability to make choices in science classes, interest in science, usefulness of science and science classes, and career interest in science fields.

### Constructs That Influence Classroom Learning

#### Introduction

Learning theorists believe that certain classroom practices or constructs increase motivation to learn. Table 3 is a review of the literature for each of the four learning theories. Each learning theory emphasizes different constructs as illustrated in Table 3. The behaviorists have the fewest constructs, because they look at stimuli as the determining factors of motivation. Humanists and cognitive theorists incorporate all seven constructs as essential to their learning theories. The constructivists incorporate all of the constructs into their learning theory; however the four constructs of enjoyment of learning, lack of anxiety in learning, relevance of learning, and career interests are so prominent that they stand out above the other three. The rationale for a literature review dealing with the motivational value of these constructs is that both the quantitative and

qualitative data collected in this study assesses how well the HUNCH classroom incorporates these constructs into its activities.

The quantitative SIMSQ questionnaire can be broken down into seven specific constructs. The questionnaire asks students to provide feedback that allows the researcher to evaluate student perception of how well HUNCH activities incorporate these constructs. A strong positive response for a question such as “How often has HUNCH class made you feel successful?” would suggest that students feel successful in HUNCH classes. Qualitative data was also collected, which included student focus groups and individual student interviews, which adds credence and understanding to the quantitative data. While the quantitative data collection is limited to seven constructs, the qualitative data collection is open-ended to allow for emerging constructs.

Table 3. Learning Theories and Their Related Constructs.

	Enjoyment of learning	Self- concept of ability	Anxiety in learning	Ability to make choices	Interests	Usefulness of learning	Career interest
Behaviorists			X		X	X	
Humanists	X	X	X	X	X	X	X
Cognitive Theorists	X	X	X	X	X	X	X
Constructivists	X		X		X	X	

The following section is a literature review of the constructs for the learning theories. The seven constructs were used by Hassan (2008) to assess his *Student Interests and Motivation Science Questionnaire*. Hassan chose these constructs after an extensive

literature review of motivational constructs that are most relevant for studying students' motivation of science learning.

### Enjoyment of Learning

It is a commonly held belief that students learn best when they enjoy what they are learning. All learning theorists are advocates for the inclusion of enjoyment of learning in classrooms; however, the humanists, cognitive theorists, and constructivists are the most adamant with regard to implementing enjoyment of learning into classroom practices.

The research in this section for enjoyment of learning aligns best with the cognitive theorists and constructivists such as Weiner and Vygotsky. Weiner's attribution theory and Vygotsky's work on the Zone of Proximal Development advocate that learning should take place at a challenging level, but within reach of students' ability to succeed. Both theorists suggest that learning is more enjoyable when a challenge is present (Vygotsky, 1997; Ames & Ames, 1984). A good example of this is sports. There is an extra degree of enjoyment when a team wins against its most challenging rival.

Educational research and common sense verifies that when students enjoy a class they will pay better attention and be motivated to learn (Barmby et al., 2008). Research indicates that the more students enjoy learning the better they retain the information (Stipek & Seal, 2001). In an experiment, University of Rochester psychologist Richard Ryan allowed ninety-two college students to choose between two readings, and the students rated their enjoyment of these readings. Then the students wrote all they could remember about the readings. A positive correlation existed between the rating of

enjoyment of the readings and students' understanding and recall of the readings (Stipek & Seal, 2001).

Research conducted by Barmby, Kind, and Jones (2008) indicates that there is a positive correlation between enjoyment of science classes and career choices in scientific fields. However, research shows that enjoyment of science classes decreases as students advance to higher-level courses (Osborne et al., 2003; Reiss, 2004). A meta-analysis of research on attitudes toward science by Osborne et al. (2003) found that children enter secondary school with positive attitudes toward science courses and careers. However, these attitudes become increasingly more negative by the time they graduate from high school. Osborne et al. (2003) concludes that the problem is not due to the level of difficulty of the science courses as much as to science courses having too much recall and copying, along with a lack of intellectual challenge for students (Osborne et al., 2003). Reiss's (2004), long-term, 6-year, qualitative study of twenty-one students in London, substantiates Osborne's et al. (2003) conclusions. Results from Reiss's (2004) research indicated that students' enthusiasm for studying science was inversely proportional to the number of secondary science courses that they took.

The more challenging and relevant the learning activities, the more students enjoy learning (Stipek & Seal, 2001). The work of Mihaly Csikszentmihalyi (1990) on flow theory supports the use of challenging learning activities to promote enjoyment. Csikszentmihalyi suggests that enjoyable learning experiences occur, "When a person's body or mind is stretched to its limits in a voluntary effort to accomplish something difficult and worthwhile" (Csikszentmihalyi, 1990, p. 3). Csikszentmihalyi's research

concluded that opportunities and challenges are enjoyable not because of any external circumstances, but rather because of the internal consciousness of a person's cognition about the experiences. For example, Bobby Fischer, the chess champion, exists "in the flow" while enjoying a game of chess, while another person might think playing chess is pure drudgery. After extensive research, Csikszentmihalyi concludes that there are eight components of enjoyment and at least one component needs to be present for the activity to be enjoyable. The eight components are as follows:

- 1) A person has the ability to complete the task
- 2) A person is able to immerse him or herself in the task
- 3) The task has clear understandable goals
- 4) Immediate feedback is available to help the person accomplish the task
- 5) The person is so deeply involved in accomplishing the task that their awareness of the rest of the world seems to disappear
- 6) The person has a sense of control over their actions
- 7) The person is totally engaged in the task and their sense of self disappears
- 8) The person's sense of time changes; hours may seem like minutes

In conclusion, enjoyment of learning is an important construct. It promotes student learning, and interest in the learning. All students enjoy different subjects, but it is the task of teachers to maintain students' enjoyment of the subjects that they teach.

### Self-Concept of Ability

In order to involve more students in STEM careers, students' self-concept in their mathematical and scientific abilities must be bolstered (Hulleman & Harackiewicz,

2009). American students have low self-concepts in their mathematical abilities (Lee, 2007). This low self-concept in mathematics steers students away from studying courses that apply mathematics, such as science and engineering (Hulleman & Harackiewicz, 2009). If the goal is to increase the quantity of students entering STEM careers, then students' self-concept of ability in STEM courses must be improved. All learning theorists advocate for the inclusion of classroom practices to improve student self-concept of ability; however, the humanists and cognitive theorists put this construct at the top of their list.

How one perceives one's abilities has an impact on how one acts, what challenges one undertakes, and how long one persists on tasks (Lee, 2007). The leading theorists who promote the importance of one's perception of one's ability are the humanists, such as Keller and the social cognitive theorists such as Bandura. Bandura (1994) and his followers advocated for the importance of self-efficacy or belief in one's own abilities to succeed at any given task. Self-efficacy is expanded on by the humanists, who believe that self-concept, which defines one's perceptions of one's abilities in general, plays a vital part in learning (Keller, 2000). Both Keller and Bandura suggest that education should strive to build the best possible perception of one's self-concept. They believe that a person's actions are not controlled by events (as the behaviorists believe) but how a person perceives those events. Thus, educational practices should provide students with experiences that promote confidence and improve a student's self-concept of ability.

Cognitive theorists suggest that self-efficacy or a person's perception of the probability of successfully completing a task is vital for promoting academic

achievement (Bandura, 1994; Lee, 2007; Jain & Dowson, 2009). Self-efficacy research is supported by numerous studies. For example, Bouffard-Bouchard, Parent, and Larivee (1991) found that when ability is not a factor, junior and senior high school students with high levels of self-efficacy score significantly higher on reading scores than their peers who were considered to have low levels of self-efficacy. Their findings suggest that a student's self-efficacy beliefs are directly proportional to their reading achievement. The implication of this study is that a student's self-efficacy significantly influences academic achievement (Bouffard-Bouchard et al., 1991).

To summarize, if students believe that they will succeed, this belief promotes academic success. Even more importantly students' positive belief in their abilities allows them to make choices and take risks that they might otherwise not even attempt. This is especially important when looking at science and mathematics courses in high school. If students do not have a positive self-efficacy in these areas, they will often avoid these subjects, never really allowing themselves the opportunity to improve their skills.

### Influence of Anxiety on Learning

If innovative classroom programs are going to encourage learning in STEM classrooms, then they must promote classroom practices that lead to stress-free learning (Burns, 1998; Stipek, 2002). In today's STEM classrooms, anxiety is too often present, especially for female and minority students (Corbett et al., 2008). All learning theorists believe that high levels of anxiety in the classroom are detrimental. The following



discusses the reasons for anxiety and some classroom practices that help to reduce or eliminate anxiety in the classroom.

The most well-known form of anxiety in STEM areas deals with math anxiety. Much has been researched and written about math anxiety and its detrimental effects that may last a lifetime. Marilyn Burns (1998) wrote a book called *Math: Facing an American Phobia*, in which she relates horror stories that people have told her about why they fear and dislike math. Burns's interviewees viewed mathematics with dread, dismay, anxiety, and more. Their stories tell of teachers who made them feel inadequate when they could not do calculations fast or accurately enough. These people grew up believing that math was something other people could do, but not them (Burns, 1998).

While Burns (1998) writes about mathematics as being an American phobia, a cross-cultural study by Lee (2007) finds mathematics to be an international phobia. Of the 250,000 fifteen-year-olds in 41 countries that participated in the 2003 Programme for International Student Assessment (PISA), more than half of the countries surveyed exhibited mathematics anxiety levels greater than that of American students. Mathematics anxiety effects students' ability and confidence in mathematics. Chinn (2008) described mathematics anxiety as a threatening condition that leads to fear, which interferes with math ability. This is exactly the results that Jain and Dowson (2009) found when they studied 232 eighth graders in India by administering the Motivated Strategies for Learning Questionnaire and the Mathematics Anxiety Scale. Jain and Dowson's research suggests that math self-efficacy (as defined as the level of confidence students

have in their abilities to do particular mathematical tasks) directly affects mathematics anxiety, and that this construct has a strong influence on mathematical achievement.

Anxiety in the Classroom. Research supports the fact that anxiety in small measures can put a person in a heightened state of performance, especially if the performance is not too difficult for the person (Stipek, 2002). However, research by Tobias (1979) involving various levels of anxiety, found that high levels of anxiety significantly interfered with the following three stages of learning: preprocessing of information, processing of new material, and retrieving of information (Tobias, 1979). With regard to the first stage, preprocessing of information, Tobias (1979) found that high levels of anxiety interfered with the attention that students were able to apply to new material. Anxious students worried about learning and were preoccupied with thinking about negative situations in which they previously had failed (Tobias, 1979). Poor attention at the preprocessing level of learning does not allow the acquisition of new knowledge. The second stage of learning that anxiety interferes with is the processing of new material. Anxiety during processing of learning occurs when learning involves new material that is too difficult and requires too much recall (Tobias, 1979). During the third stage of learning, highly anxious students often complain of failing to recall information or “freezing up” (Tobias, 1979).

Tobias’s research (1979) includes proven ways to overcome anxiety in learning. Tobias suggests that allowing students the opportunities to review new material as needed reduces anxiety. This practice relieves the anxiety brought about when students feel they must learn new material the first time it is introduced. Tobias also suggests that self-

paced instruction keeps students from worrying about keeping up with others.

Furthermore, Tobias states that giving students access to any information that they may need for background knowledge can reduce anxiety. Finally, Tobias's research found that students' output improved by giving them an opportunity to correct their errors. Failure viewed as a learning opportunity and not as a source of embarrassment leads to academic motivation (Stipek, 2002).

There are several explanations for anxiety in the classroom. One is that students do not have a good understanding of the subject material; therefore, they feel anxious (Stipek, 2002). Anxiety in this situation only makes learning more difficult by interfering with the learning of new material as demonstrated by Tobias's (1979) research. Another explanation is that students have a low self-concept of their abilities and dwell on their deficiencies by envisioning failure (Stipek, 2002; Tobias, 1979). In school, a history of failures leads to low self-confidence and high anxiety. Anxiety in the classroom is more prominent when failures are salient (Stipek, 2002). All four learning theories include procedures that try to control the level of anxiety in learning. The theories vary in the causes and solutions for controlling anxiety, but they all agree that high levels of anxiety hinder students' motivation to learn.

Anxiety and Learning Theories. According to behaviorists, anxiety is a learned response to negative stimuli such as receiving failing test scores or poor grades. This theory fails to encompass all causes of anxiety, because even high-achieving students who have not received negative stimuli can still experience high levels of anxiety. Their anxiety may be the result of parent, peer, or self-pressure to continually do exceptionally

well and the ever-present fear of failing (Stipek, 2002). Behaviorists examine the external stimuli that are causing the anxiety and try to eliminate it in the classroom. For example, if failing test scores are the causative stimuli, then giving students a chance to improve their scores eliminates some of the anxiety.

Humanists believe that anxiety is a product of how the person views his or her successes and failures. Classrooms where students view themselves as failures do not provide the level of emotional safety that Maslow (1943) advocates in his hierarchy of needs. Humanists promote tasks that students can accomplish successfully without high levels of anxiety.

Cognitive theorists take a close look at the cognition behind anxiety. Cognitive theorists are interested in determining if anxiety is either trait or state anxiety (Stipek, 2002). Trait anxiety is a stable characteristic of a person that is not easily changeable. A person with a high level of trait anxiety has a personality that promotes anxiety in all aspects of their life. There is little that teachers can do to eliminate trait anxiety. However, state anxiety is a temporary state caused by a specific task or situation. When students do not feel capable of accomplishing a specific task, state anxiety becomes apparent. Teachers and students can take many steps to lower state anxiety. Atkinson's equation of motivation to achieve verifies that tasks should be in the middle range of students' probabilities that they will successfully complete the task (expectancy value of 0.5). Any higher or lower expectancy values not only decrease motivation (see Table 2) but also lead to increased anxiety (Lee, 2003). When a task is easy, the thought of failure leads to anxiety due to an increased level of embarrassment, if failure occurs. When a

task is too difficult, students may think they are going to fail and this cognitive thinking leads to increased levels of anxiety (Tobias, 1979).

The constructivists suggest that understanding a child's Zone of Proximal Development and teaching in that learning level reduces the negative effects of anxiety on learning. Vygotsky (1997) theorized that all learning should occur in students' Zone of Proximal Development, supported with scaffolding by the teacher to insure success. Piaget was concerned with ensuring that learning tasks matched students' stages of development. For example, he believed that students should not attempt abstract learning until they are at least eleven years old and in their formal operational stage of development. Furthermore, Piaget hypothesized that if abstract learning occurred before this stage, failure and anxiety could develop (Driscoll, 2000).

In summary, high levels of anxiety lead to problems with learning. Classroom practices can lower students' levels of anxiety by allowing students to work at their own pace, receive help as needed, and redo their work so that failure is not an option. The practice of students working in their Zone of Proximal Development, with scaffolding by the teacher, is a major contributor to lowering student anxiety in the classroom.

### Ability to Make Choices

Of all the motivational constructs, the ability to provide choices in the classroom is one of the best ways to promote intrinsic motivation to learn and to allow for creativity (Amabile & Hennessey, 1992). Einstein, in his autobiography, discussed the lack of choices in his high school science class, and the influence it had on his academic motivation. Einstein wrote the following about his science class: "This coercion had such

a deterring effect upon me that, after I had passed the final examination, I found the consideration of any scientific problem distasteful to me for an entire year” (Amabile & Hennessey, 1992, p. 54). Einstein left this highly regimented school to enroll in a school that had a humanistic approach to learning. This allowed Einstein’s creativity and individual interests to flourish, since education at his new school focused on individual choices. In fact, it was at this school where Einstein began to develop his theory of relativity (Amabile & Hennessey, 1992). The humanists and cognitive theorists are the strongest proponents for student choices in the classroom. The following section discusses why students’ ability to make choices is such an important academic motivational classroom practice.

Research continually indicates that the ability to make choices in the classroom is vital to academic motivation (Kohn, 2005; Osborne et al., 2003; Heyl, 2008; Kinzie, Sullivan, & Berdel, 1988; Shih, 2008). Kohn’s (2005) research, for example, indicates that classrooms where students are given choices are characterized by “Greater perceived competence, higher intrinsic motivation, more positive emotionality, enhanced creativity, a preference for optimal challenge over easy success, greater persistence in school, greater conceptual understanding, and better academic performance” (Kohn, 2005, p. 12). Research continually suggests that the ability to make choices in the classroom is vital to academic motivation (Kohn, 2005; Osborne et al., 2003; Heyl, 2008; Kinzie et al., 1988; Shih, 2008).

Offering students choices allows them to move in the direction that is most meaningful to them. A democratic classroom environment empowers students and

motivates them to perform at the highest levels of academic achievement (Osborne et al., 2003). Developmentally, adolescents have a need to create their own voice through learning. This occurs nicely when students can make choices (Heyl, 2008). Osborne's et al. (2003) meta-analysis of motivational research indicated that two of the essential ingredients of motivation are the opportunities to make choices and the ability to exercise some control over what is learned. Results from studies investigating factors thought to motivate learning suggest that there is a positive correlation between the ability to make choices and intrinsic motivation (Kohn, 2005; Kinzie et al., 1988; Shih, 2008).

Recent research by Shih (2008) examined the differences in intrinsic motivation and the autonomy of classrooms in Taiwan. Shih's (2008) study involved 343 Taiwanese eighth-grade students enrolled in either autocratic teacher-controlled classrooms or autonomous classrooms where students had the opportunity to make choices for themselves. Results from an intrinsic motivational study found significant differences in intrinsic motivation based on the level of perceived classroom autonomy. Eighth-grade students enrolled in autonomous classrooms indicated higher levels of intrinsic motivation than those in teacher-controlled classrooms (Shih, 2008).

Cognitive learning theorists emphasize the significance of the ability to make choices in their attribution theory, self-determination theory, and expectancy theory. Attribution theory's internal locus of control predicts academic motivation by the level of students' control over their learning. Students have an increased internal locus of control when their choices become the controlling factor in their learning (Ames & Ames, 1984). Students' attitudes, achievements, levels of anxiety, and motivation improve when they

perceive that they are in charge of their education (Kohn, 2005; Kinzie et al., 1988; Shih, 2008).

The theory of self-determination (SDT) is a psychological theory that involves the amount of intrinsic motivation that develops by allowing for self-determined choices (Shih, 2008). During the school day, students move according to a schedule and listen to teachers' prepared instructions. Students may not gain a sense of control or a feeling of self-determination. Students often feel that their interests and abilities are irrelevant (Osborne et al., 2003). According to SDT, intrinsic motivation develops by students initiating their learning based on their choices and by their own volition. An autonomous supportive classroom has the following characteristics: opportunities for student choice, importance of individuals' needs, allowing students to solve their problems in their own way, encouraging students to experiment, and minimizing the demands on students. Autonomous supportive classrooms promote the growth of students' intrinsic motivation (Shih, 2008).

Atkinson's expectancy theory indicates the importance of choices by valuing the incentive factor. The incentive factor is the attractiveness or interest of students in specific activities. Activities chosen by students may be more interesting to them than those assigned by teachers. Therefore, incentive values increase with a student's ability to choose. The incentive value in expectancy theory is directly proportional to the level of motivation to succeed (Atkinson, 1957). Atkinson, along with other cognitive theorists, acknowledges the motivational value of students' ability to make choices (Atkinson, 1957; Bandura, 1997; Pintrich & Schunk, 2002; Ames & Ames, 1984).



Whether learning theorists define motivation from within oneself as an internal locus of control, intrinsic motivation, self-determination, or autonomy, they all agree that the ability of students to follow their interests and abilities is a vital component of motivational practices. It is imperative that teachers keep students' individual needs and interests alive, in order to foster motivation and support sustained task performance with high levels of academic achievement (Stipek, 2002).

### Interest and Attitudes in Learning

When a student is interested in learning something, their desire to know all they can about that subject is a strong motivating force. It might take some students longer, or it might require more work from certain students, but all normal students can learn all subjects if they are interested enough in the subject. It is a matter of how much time and energy a student is willing to put into learning.

The work of researchers involved in all four learning theories has shown the importance of interest to academic achievement and motivation to learn (Schiefele, 1991; Athanasou & Petoumenos, 1994; Athanasou & Cooksey, 2001; Stipek, 2002; Osborne et al., 2003). The following section defines interests and discusses why classroom practices should promote activities involving students' interests.

Schiefele (1991) divides interest into two categories, situational and individual interest. Situational interest is an emotional state of interest that is due to situational stimuli. Situational interest in education involves factors such as study time, homework time, quality of teaching, difficulty of subject, and subject relevance (Athanasou & Cooksey, 2001). These factors fluctuate and are influenced by the students' environment.

For example, one year a student may have a teacher who inspires students to become scientists, because of his or her enthusiasm and creative teaching skills. However, the next year the student can have a teacher who does a poor job of exciting students about science and so the student loses interest in science. Another example would be a student who does not have an after school job so he or she can devote time for studies and homework. However, the next year the student has a job that occupies his or her time after school. These factors are all components of situational interest that affect a student's motivation to learn (Athanasou & Cooksey, 2001).

Individual interest factors are the inherent characteristics of students such as their ability in a particular subject (Athanasou & Cooksey, 2001). Individual interest applies to students' preferences for one subject, over an extended period, not just while they are involved in a particular class or situation (Schiefele, 1991). The development of individual interest over the life span of a student depends on many different factors that include both internal characteristics of the student and external experiences. Osborne's et al. (2003) meta-research findings clearly confirm that early positive childhood experiences that involve enjoyment, and interest in science lead to individualized interest in science when coupled with student ability. Why one student likes science and the other likes English has to do with the constructs that characterize the students' interest in the subject. Figure 1 models the components of interest attributable to situational and individual interests.

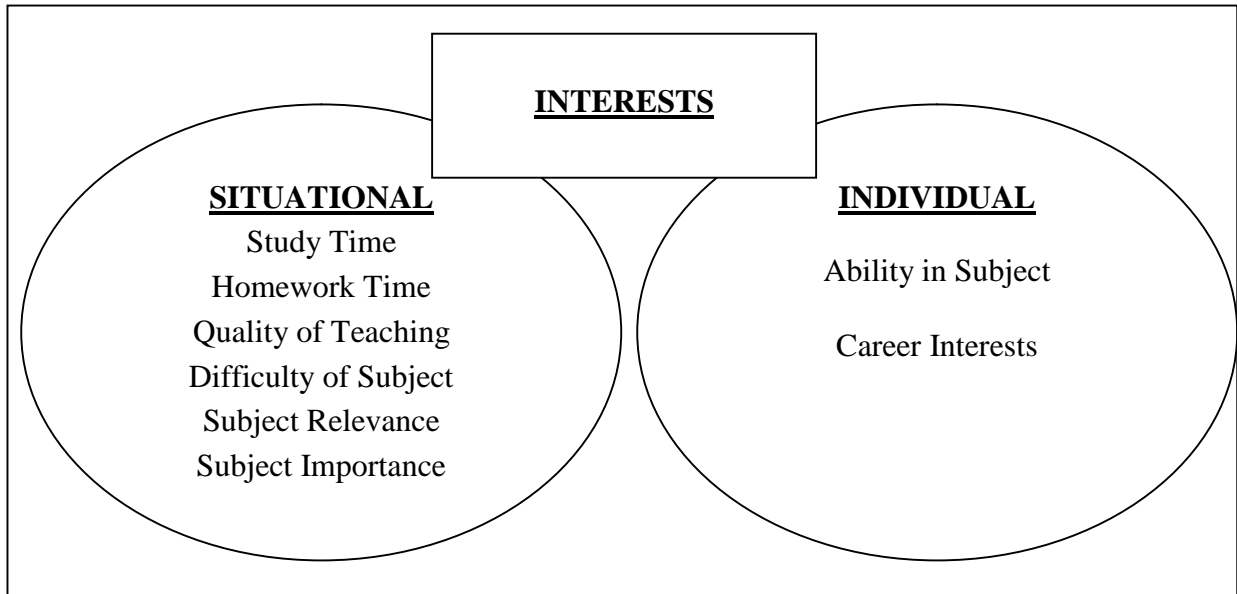


Figure 1. Model of Interests Composed of Situational and Individual Interests  
 Note. Adapted from “Judgement of Factors Influencing Interest: An Australian Study,”  
 by J.A Athanasou, and R.A. Cooksey, 2001, *Journal of Vocational Education Research*,  
 26, p. 2).

The constructs of enjoyment of subject, lack of anxiety in the subject, ability to make choices, and the students’ perceived relevance of the subject area all contribute to students’ latent and actualized characteristics of individual interests. However, it is the construct of self-concept of ability, which research has shown to have the most control on influencing interest (Bottoms & Uhn, 2007). Stipek (2002) studied junior and senior high school students using self-report questionnaires on their perceptions of competence and their individual interest in a subject that they were learning. Her study found that as student’s perceived competencies increased so did their interests. Stipek’s research also found that as students’ perceived competencies decreased so did their interests (Stipek, 2002).

Stipek's research suggests that STEM educators should ask the following questions: Is interest in STEM courses due to perceived competency in STEM courses? Moreover, what can teachers do to increase students' perceived competency in STEM courses? Recent research on student attitudes toward science has brought these questions to the forefront of certain educational studies.

Barmby, Kind, and Jones, 2008, conducted research similar to Stipek's yet focused on science. Their research found that a positive attitude about ones' abilities in science equates to perceived competency in science, along with a desire to learn science. Barmby's et al. (2008) research suggests that the decline in positive attitudes toward school science is linked to the number of science courses taken in high school. Students' attitudes decline as they enroll in more science courses. Their findings support research conducted by Osborne et al. (2003) and Reiss (2004) and indicates an immediate need for research to identify interventions to stop the decline of students' attitudes toward school science.

All four learning theories consider interest and positive attitudes motivating factors toward learning. The behaviorists propose that extrinsic stimuli that result in positive reinforcement promote individual and situational interests. The humanists, however, suggest that children are born with latent individual interests and that in order to motivate students, their individual interests must be cultivated. Cognitive theorists such as Bandura, Atkinson, and Weiner advocate that self-concept, which results in perceived competency, is the most important factor in promoting a positive attitude toward a subject. The constructivists, on the other hand, propose that students' attitudes

and interests in a subject develop from students' abilities to develop interests from positive experiences. Educators must consider the motivational practices from all the theorists, in an effort to thwart the decline of interest in STEM subjects.

In summary, interest is directly related to many motivational constructs; however, the most salient is students' perceived ability in a subject. If a student perceives him or herself as competent in a subject area, then this perception may promote interest. It is the aim of STEM education to provide experiences for students in which their perceived abilities will improve and therefore, allow for the development of both situational and individual interests.

### Relevance of Learning

Perceived relevance of learning has proven to be another good way to increase interest and improve attitudes toward a subject. A working description of usefulness or relevance in education involves using real-world examples from current and local issues that relate the theory learned in the classroom to its applied uses and values (Kember, Ho, & Hong, 2008). Authentic learning opportunities and fieldwork that applies school learning to real-world applications motivates students to learn by demonstrating to them the value of their knowledge (Kember et al, 2008). Research by Benware and Deci (1984) divided college students into two random groups in order to demonstrate the relevance of learning to academic motivation. The first group was told that they were to read a passage on neuroanatomy and to be ready to teach it to others, which made the learning useful. The other group was instructed to read the same passage and to be ready to take a written exam on the material. Both groups had three hours to study the material. Benware and

Deci found that the group that was to teach the material had significantly better scores on a comprehensive exam of the material.

Without knowing the relevance of their studies, the purpose of the learning becomes to receive good grades. While the desire to receive good grades is a form of extrinsic motivation, it is less powerful than intrinsic motivation to learn. Shih (2008) states, “When people recognize the personal relevance of an activity, they are more likely to engage in the activity volitionally and willingly” (Shih, 2008, p. 314). Because of the importance of relevance to student learning, all four learning theories place the practice of making learning relevant on the top of their lists for best classroom practices. The following section will discuss what researchers have studied about the importance of relevance.

Kember, Ho & Hong (2008) interviewed 36 undergraduate students in Hong Kong to determine factors that motivated them to study. Results from their research found that student motivation improved when they knew how the classroom learning relates to real-life situations. Kember’s et al. (2008) study identified the following eight factors as supporting and sustaining learning: relevance in learning, establishing interest, allowing choice of courses, using learning activities (discussions and hands on projects), teaching for understanding, assessment (on what was actually learned in class), close teacher-student relationships, and a sense of belonging between classmates. Kember et al. (2008) placed *establishing relevance* at the top of the list because of the frequency and emphasis that students mentioned relevance of learning. He concluded his research by

stating, “If teachers wish to motivate their students’ learning, they need to find ways to show the relevance of topics included in their courses” (Kember et al., 2008, p.255).

All four learning theories advocate that students’ learning should focus on the students’ interests, abilities, and talents, which makes the learning relevant to students. According to the behaviorists, the best way to motivate is to use positive reinforcement that is relevant to students. It is a teacher’s responsibility to determine the most relevant positive reinforcements (Kolesnik, 1975). The humanists apply Keller’s ARCS theory of motivation to learning. The R stands for relevance. Keller suggests that relevance motivates learning when learning correlates with the students’ interests and goals (Keller, 2008). The cognitive theorists rely on relevance of learning as a component of the incentive factor in expectancy theory. Atkinson defines the incentive factor as, “The relative attractiveness of a specific goal that is offered in a situation” (Atkinson, 1957, p.360). The attractiveness of a specific goal is in large part due to the students’ perceived relevance of the activity. The constructivists have coined the phrase “authentic learning experiences” to define activities that are relevant to students’ goals and real-world situations (Kember, 2008). Vygotsky (1997) advocated that schools should value each individual’s interests, abilities, and goals. He theorized that schools should be molded by the students and not the students molded by the school. Vygotsky’s notion of constructivism placed emphasis on teachers as facilitators to guide students in the directions that the students felt were relevant to them.

Relevance in the Science Classroom. It is clear that the study of mathematics, science, and engineering in today’s world is very relevant considering the ever-present

issues related to technology, global warming, energy shortages, and space exploration. However, Osborne's et al. (2003) meta-research has found that students do not view school science classes as relevant. Results from their research suggest that the retrospective teaching of science courses may be responsible for students' perceptions that science content is not relevant to their daily lives. Much of the time devoted to teaching science is focused on the history of science and classical scientists rather than on the modern day scientists who are responsible for significant scientific findings in the 21<sup>st</sup> century (Osborne et al., 2003). Results from interviews with students conducted by Reiss (2004) found that students want school science to be more relevant and useful in their lives. The lack of relevance in science instruction was also a matter of concern at the 2003 World Conference in Science and Technology Education. This organization called for the need to make science education more relevant to students' interests and to the needs of society (Teppo & Rannikmäe, 2004).

Science programs that have successfully connected students to real-world situations have developed highly motivated students with positive levels of achievement, engagement, and interest in scientific careers (Heyl, 2008). Science classrooms across the nation are developing courses that link students with productive, real-world activities that are valued by society. It is the researcher's observation of this ability of NASA's HUNCH program that has led to this study.

In conclusion, learning theorists agree that relevance of learning is a major contributor to interest and therefore to academic motivation. Research substantiates the power of relevance to learning. Every high school mathematics teacher will attest to the



fact that they are often asked by well-meaning students, “When are we ever going to use this?” The answer to this question needs to be apparent to students, especially if they are going to be motivated to study challenging mathematics and STEM courses.

### Career Interest

If a student already has an interest in becoming a scientist or engineer, then they will be highly motivated to study courses that assist them in reaching their career goals (Stipek, 2002; Heyl, 2008). No one understands this more than the humanists and cognitive theorists who believe students’ goals should lead the way in students’ education. The humanists want to provide students with choices that allow them to pursue their interests and goals. The cognitive theorists believe that students’ motivation to succeed is greatly increased when they have an incentive or motive behind their learning (Atkinson, 1957). The following section discusses research that demonstrates the influence of career interest on motivation to learn.

Most high school students have not determined their career paths. However, for those students who know what they want to become, their desire to study all that is required in their chosen field becomes paramount (Stipek, 2002; Heyl, 2008). Athanasou and Cooksey (2001) used scenarios to determine what factors are best in motivating student interest in a subject that would lead to a career. They found that an individual interest such as interest in a subject due to career goals was an important motivating factor (Athanasou & Cooksey, 2001). For example, if a student wants to be an engineer, then he or she would be highly motivated to study mathematics and sciences, which are related to engineering. Career interests involve all of the motivational constructs that are

discussed in this chapter. Students choose careers that they find enjoyable, interesting, and relevant. However, career interest in a subject is most significantly affected by students' perceived ability in the subject (Athanasou & Petoumenos, 1994).

The recruitment and retention of enthusiastic STEM teachers is essential for promoting and sustaining student situational interest in science content (Osborne et al., 2003). This assertion is further supported by Reiss's (2004) research, which found that teachers play a significant role in influencing student career choices. In Reiss's qualitative study, he examined the attitudes toward science of four students for six years, from ages 11 to 17. In interviews with the students, he found that the characteristics of the teachers' teaching abilities played an essential role in influencing students' attitudes toward science. The characteristics such as the ability to explain lessons and the ability to make the lessons enjoyable were important in shaping students' likes or dislikes for a science course, not the actual material learned (Reiss, 2004).

Organizations that depend on scientists, technicians, engineers, and mathematicians have a huge stake in promoting STEM career choices. Over the past decade, they have taken a more active role in supporting educational programs by donating time, money, equipment, and expertise to help promote STEM courses in schools (Demski, 2009). The number of students choosing careers in engineering and scientific fields is diminishing in United States and certain European countries (Osborne et al., 2003; Kind et al., 2007). Nevertheless, society's need for professionals in these fields is increasing (Friedman, 2005). The concern of educators and society alike is to learn what can be done to prevent this decline of career interest in STEM area.

National Efforts to Promote Interest in Science,  
Technology, Engineering, and Math Careers

Introduction

There exist a plethora of programs to promote student interest in STEM areas. Many of the programs consist of competitions or after school activities. However, there are a growing number of magnet schools and academies that are designed specifically to promote STEM curricula (Katehi, Pearson, & Feder, 2009). This research briefly exams Project Lead the Way, one of the most prevalent programs that promote instruction in engineering disciplines. The Physics First program is also examined, which is documented in a doctoral dissertation by Goodman of Rutgers University. The reason behind the choice of Project Lead the Way is because the rules of participation in the program require schools to partner with other businesses or organizations. One PLTW school that participated in this study used their HUNCH project as their partner organization. The Physics First program was chosen because the program is well documented and its results indicate the importance of providing students with applications of their learning concurrently with their acquisition of concepts in mathematics.

Finally, the research takes an in-depth look at the structure of the HUNCH program. Table 4 summarizes the constructs that are prevalent in these three programs.

Table 4. Prevalent Motivational Constructs of STEM Programs

Motivational Constructs	Enjoyment	Self-Concept	Lack of Anxiety	Ability to make Choices	Interests	Usefulness	Career Interest
Project Lead the Way				X	X	X	X
Physics First						X	
HUNCH	X	X		X	X	X	X

### Project Lead The Way

Project Lead The Way (PLTW) is a non-profit program designed to attract greater numbers of students into engineering fields (<http://www.pltw.org>). PLTW was founded by Richard Blais and Richard Liebich who wrote, “When schools apply activities and problem-based learning, they generate an increase in student motivation, an increase in cooperative learning skills, higher order thinking, and an improvement in student achievement” (Education Commission of the States, 2009, p.1). This philosophy has made PLTW an award winning innovative school-based program (Education Commission of the States, 2009).

A 2006-2007 assessment of PLTW by the National Center for Education Statistics found that, “PLTW students select engineering at five to ten times the rate of typical students” (Walcerx, 2007, p. 3). An evaluation of the impact of PLTW on students’ interest in studying STEM courses found that twenty-three percent more PLTW students completed four years of high school mathematics and twenty-five percent more completed three years of high school science courses when compared to comparable career technical students (Bottoms & Uhn, 2007).

PLTW's program is mainly based on the motivational constructs of relevance of learning and career interests. PLTW aims to expose and engage students in learning activities that are relevant to the fields of engineering. Students learn that their academic mathematics and science knowledge when applied to engineering problems are essential skills for engineering.

### Physics First

From concepts that initially developed in the 1960's, Physics First came to national attention in 1995 when Leon Lederman promoted the idea of teaching physics before biology and chemistry in high schools (Goodman, 2006). To succeed in physics courses, students must apply algebra. Therefore, learning physics at the same time as algebra allows students to apply what they learn in algebra class to their physics class. This provides relevance to students while they are learning algebra. To implement Physics First, both the physics and algebra curricula must be rewritten to complement each other. Results from Goodman's (2006) doctoral research suggest that increases in student aptitude in both mathematics and science were related to their involvement in the Physics First program.

### NASA Programs

NASA has over thirty major educational projects for secondary students (<http://search.nasa.gov/search/search.jsp?nasaInclude=educational+programs>). These projects are educational activities that take place both inside and outside the classroom. NASA either sponsors or co-sponsors these activities. High schools throughout the

country participate in the many challenging and educational programs that NASA helps to sponsor. The HUNCH program is a good example of one of NASA's newer educational programs.

### The HUNCH Program

As with all great ideas, necessity often provides the spark to ignite the flame. NASA's HUNCH program came out of the necessity to supply Marshall Space Flight Center (MSFC) with cost-efficient hardware for training International Space Station (ISS) astronauts. Stacy Hale from Johnson Space Center (JSC) and Robert Zeek from Marshall Space Flight Center (MSFC) had the task of supplying training hardware for ISS astronauts within a limited budget. The unique idea for the fabrication of the training hardware by high school students came after Hale visited his son's Agricultural Metal Fabrication class at Clear Creek High School in League City, Texas. The class had constructed a barbeque pit that was so well constructed that Hale felt that high school students might be able to build training hardware for NASA. With this creative idea, the HUNCH program was born in the summer of 2003 (Davis, 2004). Initially, the HUNCH program was to help fulfill NASA's need for acquiring cost-effective hardware for training the ISS astronauts. However, it quickly became apparent to all involved in the HUNCH program that NASA was achieving more than cost-effective hardware. In fact, the HUNCH program was helping NASA meet all three of its educational goals that follow and are detailed in Appendix A:

1. To strengthen NASA's future workforce by contributing to the development of critical thinking skills and interests in STEM areas

2. To improve the quality of STEM educational programs
3. To build partnerships with educational institutions (“NASA’S Planned Investments in Education,” 2006).

### NASA’s First Educational Goal

NASA’s first educational goal has two purposes. First, it aims to insure that NASA’s future workforce has the necessary skills to solve the challenging and unknown questions of space exploration. The HUNCH program aims to engage students in challenging hands-on projects that require high levels of technical skills along with the constant application of critical thinking and problem-solving skills. The second purpose of this goal is to promote interest in STEM areas. The HUNCH program reaches beyond academic science courses and involves machine shop, industrial engineering, auto body repair, metal fabrication, electronics, engineering design, drafting, and wood shop classes. By exposing students in a great variety of courses to STEM projects, the HUNCH program aims to interest a greater diversity of students in STEM areas.

The first students involved with the HUNCH program were from Clear Creek High School’s industrial mechanics class taught by William Gibbs in League City, Texas. HUNCH students from these schools received equipment, material, and blueprints from NASA to build thirty custom-designed, metal storage lockers that served to train astronauts at MSFC. Appendix B shows a picture of the locker built by HUNCH students. Each box had a total contractor cost of \$2,000. However, students could construct them at one-fifth of that cost (Hale, 2009).

Building lockers is challenging for the instructors and students. Therefore HUNCH students and teachers often work hand-in-hand with NASA engineers. The challenges of building the lockers or hardware for NASA promote critical thinking abilities, which are needed to solve the many problems that present themselves in fabrication of the hardware for NASA. Gibbs says, “I try to do projects that are complicated so that they can know they can stretch themselves and be successful” (Davis, 2004, p.2).

#### NASA’s Second Educational Goal

NASA’s second education goal seeks to improve STEM educational courses. The HUNCH program provides the opportunity for STEM courses to participate in hands-on, real-world projects. Each year the HUNCH program has developed new projects to further improve STEM educational courses. Over the years, HUNCH has expanded from building training hardware to the construction of flight certified hardware. In 2009-2010, some HUNCH schools made cargo transfer bags that are flight certified and are proposed to fly to the ISS. Other schools worked on making videos for NASA in which students edited raw footage from the ISS (Hale, 2009). Students in schools around MSFC are partnering with NASA engineers in developing and fabricating prototypes for the Ares 1 upper stage and the J-2x engine, which supplies the power for the Ares 1 to reach orbit. These students participated in professional design meetings and teleconferences with NASA engineers (Smith, 2009). The newest program is the HUNCH National Laboratory in which students are designing, documenting, and fabricating experiments proposed to fly on the ISS. An example of an experiment is designing a plant growth chamber, which



could supply the astronauts with fresh food on the ISS. Appendix D provides a detailed example of the work involved in building a plant growth chamber.

### NASA's Third Educational Goal

The third educational goal of NASA is to build partnerships with educational institutions. The HUNCH program provides a win-win situation for NASA and schools. NASA supplies the materials, consumables, and oversight to build the hardware and the schools supply the technical direction, safe working environment, and commitment to create and build the requested hardware.

NASA wins in this partnership by obtaining cost-effective hardware such as standoff interface panels (SIP), utility outlet panels (UOP), generic luminaire assemblies (GLA), relays, harnesses, cargo bags, single stowage lockers, a wardroom table, and much more. Student projects have furnished a complete training room for astronauts at Marshall Space Flight Center. For pictures of some of the hardware and the training room see Appendix B.

Schools win in this partnership by exposing students to real-world projects that apply their scientific, mathematic, and other technical knowledge. When the knowledge gained in science and mathematics courses are applied to relevant projects, research indicates that students will be more interested in studying these subjects. (Kember et al., 2008). Both NASA and educational institutions win when interest in STEM areas is salient in schools, communities, and the nation. Table 5 contains a summary of the HUNCH program's structure. The full HUNCH program structure can be found in Appendix C.

Table 5. Summary of the HUNCH Program Structure.

HUNCH Program Institution	National Aeronautics and Space Administration
Leaders	Stacy Hale, JSC and Bob Zeek, MSFC
Funding	ISS Payload Projects Office
Web Site	<a href="http://www.nasahunch.com">www.nasahunch.com</a>
Mission	To inspire the next generation of explorers
Fabrication of Hardware	Training hardware such as single stowage lockers and cargo transfer bags
Knowledge/Skills	Engineering design, cooperative learning, and academic & technological skills
Pedagogical Elements	Authentic learning, challenging projects, integration of STEM skills
Maturity	Started in 2003 with three schools in two states and has expanded to over 30 schools in nine states
Impact	<ul style="list-style-type: none"> <li>• Seeks to make school work more challenging</li> <li>• Seeks to improve the dropout rate, quote by student, “This experience has completely changed the way I look at school and the importance it plays in my future” (<a href="http://technology.jsc.nasa.gov/hunch_story.cfm">http://technology.jsc.nasa.gov/hunch_story.cfm</a>).</li> <li>• Seeks to improve student self-confidence</li> <li>• Seeks to increase student sense of pride and accomplishment</li> <li>• Seeks to promote student attitude that failure is not an option</li> <li>• Seeks to promote interest in NASA’s educational goals</li> </ul>
Diversity	To bring STEM education to a greater variety of students
Procedures	<ul style="list-style-type: none"> <li>• Statement of Work</li> <li>• NASA officials visit schools</li> <li>• School districts sign Space Act Agreements</li> <li>• Schools supply a safe working environment and instructional oversight</li> <li>• NASA supplies the materials, tools, and technical know how</li> </ul>
Content Standards	International Technology Education Association <ul style="list-style-type: none"> <li>• Standards 8-10 involve engineering design</li> <li>• Standards 11-13 involve acquiring abilities for technological tools</li> <li>• Standards 16, 17, 19, &amp; 20 involve understanding and use of technologies</li> </ul>
Table 5 Continued	
Federal Definition of Vocational and Technical Education	“Includes competency-based applied learning that contributes to the academic knowledge, higher-order reasoning, problem-solving skills, work attitudes, general employability skills, technical skills, and occupation-specific skills of an individual.”

The following section poses questions as to whether or not the motivational constructs are implemented as part of HUNCH classroom practices. The importance of this literature review relies on its applicability to better understand the classroom practices of innovative school-based programs, such as the HUNCH program. The following section links the HUNCH program to educational research.

#### Relationship Between the HUNCH Program and the Seven Constructs Measured in the SIMSQ

The following section poses questions that need to be answered from both the quantitative and qualitative data collection of this research. The questions posed ask if the HUNCH program provides classroom practices that incorporate each of the seven constructs. The questions are only presented in this section and then their answers are discussed in chapter 5 of this research.

Research suggests that the effectiveness of school-based programs, such as HUNCH, which are designed to motivate students to study and pursue careers in STEM areas, is dependent on the presence of Csikszentmihalyi's elements of enjoyment (Stipek & Seal, 2001; Barmby et al., 2008; Ames & Ames, 1984). The following questions can be posed to determine if enjoyment is a motivating force in these STEM courses: Are students totally absorbed in their activities? Are the activities challenging? Are the activities relevant? Do students have a set goal for each activity? Do students have a sense of control? Do students believe that they have the necessary abilities to accomplish their tasks? Since learning theorists believe so strongly in the importance of enjoyment of

a subject the qualitative and quantitative data of this research seeks to answer the aforementioned questions as they relate to enjoyment of the HUNCH program.

Motivational research indicates that self-efficacy is one of the most influential constructs for academic motivation (Bandura, 1994; Lee, 2007; Jain & Dowson, 2009). Programs that seek to motivate students must involve improving students' self-efficacy and self-concept. Accordingly, a question that must be asked when evaluating the motivational aspects of the HUNCH program is how the program influences students' self-efficacy and self-concept of abilities. If the HUNCH program leads to students' perceived improvement in self-efficacy or self-concept, then research would affirm that the program is likely to improve academic performance (Bouffard-Bouchard et al., 1991).

The construct of lack of anxiety in the HUNCH classroom is an important feature, if students are going to be motivated to study challenging subjects such as STEM courses. Students' tasks should not be too easy, because failure then leads to embarrassment, or too difficult, because extreme levels of difficulty lead to high levels of anxiety. Therefore, if educators want to motivate students in STEM areas, it is of the utmost importance that programs, such as HUNCH effectively manage anxiety to help promote learning and motivation (Tobias, 1979).

Learning theorists all agree that the ability of students to follow their interests and to be able to make choices is a vital motivational construct. In recent times, since the implementation of No Child Left Behind (NCLB) and the push for standardized curricula and testing, the autonomous class, in which teachers have the flexibility to respond to their students' individual needs and interests is losing ground. In the HUNCH classroom,

it is imperative that teachers keep students' individual needs and interests alive, in order to foster motivation, sustain task performance, and achieve high levels of task perfection (Kohn, 2005). Therefore, the data analysis will seek to determine if the HUNCH classrooms allow students the opportunity to make choices on what tasks they are to perform and how they are going to accomplish that task.

Students' interests and attitudes toward subjects greatly impact their motivation to learn specific subjects. Innovative school-based programs, such as HUNCH should promote and facilitate opportunities for students to develop their interests, by exposing them to the work of professionals in STEM areas. In addition, educators need to be aware that perceived competency of a subject coincides directly with interest in a subject (Barmby et al., 2008; Stipek, 2002). The question that remains is how do classroom practices increase interest and improve attitudes in STEM subjects. The data analysis will determine if the HUNCH program increases students' confidence and these results will be reported in chapter 5.

The construct of relevance of learning needs to be incorporated into every classroom; however, school-based innovative programs, such as HUNCH are leading the way in this endeavor. The very nature of schools collaborating with organizations, such as NASA, makes the projects relevant. In HUNCH classrooms, students build hardware or design experiments in which they need to apply their mathematics and scientific knowledge. As Homer Hickam (1998) stated in his book *October Sky* (Dell Publishing) "I had discovered that learning something, no matter how complex, wasn't hard when I had a reason to want to know it." The goal remains to incorporate relevant learning into all

STEM classrooms. The data analysis will report on student's perceptions of the relevance of STEM courses for HUNCH students. This analysis will then be discussed in chapter 5.

The last motivational construct of career interests allows for goal-oriented learning. If a student wants to be an engineer then mathematical and scientific knowledge becomes a necessity. However, the challenge in today's classrooms is to expose students to the many different STEM careers, so that they can make an informed decision about STEM careers, after being exposed to these fields. In the HUNCH classroom, students work with STEM professionals. The data analysis will report on interest of HUNCH students in STEM careers and the discussion in chapter 5 will discuss if there was an increase in interest due to students involvement in HUNCH.

In summary, the humanistic motivational model of ARCS relates well to the educational practices proposed in a HUNCH classroom. In a HUNCH classroom, *Attention* of students is obtained by presenting them with challenging, unique problems that exist when building and designing hardware. *Relevance* of student tasks is due to the relevance of the projects for NASA. An added dimension is that students must also apply their knowledge from science and mathematics courses, which makes their classroom learning relevant. As students build hardware, they are also building their *Confidence* in their abilities to accomplish a challenging task. As Hale (2006) states, "One of the best parts of my job is watching kids uncover self-confidence they never knew they had, simply because they felt like they were doing something relevant and valuable" (Hale, 2006, p.1). Finally, HUNCH projects are of real value to society, providing overall *Satisfaction*.

The HUNCH classroom practices are well aligned with learning theories that advocate for situated learning and cognitive apprenticeships where learning takes place with students of various abilities working with STEM professionals. The STEM professionals and the more advanced students provide support and act as role models to the less knowledgeable students. There is ample research that substantiates the benefits of these classroom practices (Lave & Wenger, 1991; Collins et al., 1991; Wineburg, 1998; Brown et al., 1989; Park, 2006).

Past Secretary of Education Richard Riley is often quoted as saying, “We are preparing students for jobs that don’t yet exist, using technologies that haven’t yet been invented, to solve problems we do not yet know are problems” (“The Cambrian Way,” n.d., para. 1). The question arises, Are innovative school-based programs a good way to prepare students to meet these challenges?

### Summary

Today, more than ever, there is a need to motivate students to study and pursue careers in science, technology, mathematics, and engineering. However, students are shying away from higher-level mathematics and science courses for various reasons. In order to reverse this trend, innovative school-based programs are being developed. Corporations and government agencies are promoting programs that expose students to positive experiences in STEM courses.

Learning theories involve seven constructs used to motivate learning in general and the learning of science, technology, engineering, and mathematics in particular. The

following is a list of these seven constructs: enjoyment, self-concept of ability, lack of anxiety, ability to make choices, interest, usefulness, and career interest. Each of the seven constructs relates to the four academic learning theories of the behaviorists, humanists, cognitive theorists, and constructivists in various ways and to different degrees.

The importance of learning theories and their constructs is to be able to apply these concepts to educational programs that seek to motivate students. The development of innovative school-based programs is an attempt to make science, technology, engineering, and mathematics courses more interesting to greater numbers of students. PLTW has developed engineering curricula in order to expose high school students to engineering fields. Physics First has endeavored to answer high school mathematics students' question, "When am I ever going to use this?" by linking physics courses with beginning algebra courses. This literature review examines the HUNCH program that was developed to inspire, engage, and educate the nation's youth in STEM areas.

With the world's growing reliance on technology and science, there has been a corresponding growth in technical and engineering job opportunities. While America has historically been a technology innovator, this trend is at risk due to a lack of students studying to be engineers and scientists (Friedman, 2005). In response to this void, it is important to develop programs whose purpose is to inspire students to study and pursue careers in science, technology, engineering, and mathematics (STEM).



## CHAPTER THREE

## RESEARCH METHODOLOGY

Introduction

This research investigated the HUNCH program, a school-based innovative partnership between public schools and NASA, with the educational goal of motivating students to study and pursue careers in STEM areas. To evaluate the HUNCH program, this research took a mixed-method approach that collected data quantitatively from an analysis of student responses on a Student Interests and Motivation in Science Questionnaire (SIMSQ) and qualitatively from an analysis of focus groups and individual student interviews of HUNCH participants. This research answers the following four questions:

- (1) How do students who participate in HUNCH programs perceive STEM HUNCH courses and other STEM courses?
- (2) How do students who participate in HUNCH programs perceive STEM related careers?
- (3) What learning experiences do HUNCH students describe as motivating them toward pursuing courses and careers in STEM areas?
- (4) Do students who have fewer than two semesters in HUNCH perceive STEM courses and careers differently than students who have participated in three or more semesters in HUNCH?

## Context of Study

### Participants

The participants of this study were students from four states: Texas, Alabama, Tennessee, and Montana, who attended both career and technical schools and comprehensive high schools. High school students, teachers, and NASA officials, who were involved with the HUNCH program, participated in various ways in this study. Specifically, there were 169 current students, all of which were enrolled in elective STEM HUNCH classrooms, and one graduated HUNCH student who participated, along with 10 HUNCH high school teachers. Most of these participants came from areas around Johnson Space Center (JSC) located in Houston, TX or Marshall Space Flight Center (MSFC) located in Huntsville, AL.

Demographic information that was gathered from questions included on the first page of the student questionnaire (Appendix H) involved gender, class, and science grades of participants. Of the 169 high school participants in this research, 27 (16.1%) of them were female, 141 (83.9%) were male. Seventy-six (45.3%) of students were seniors, fifty-three (31.5%) were juniors, twenty-six (15.5%) were sophomores, and thirteen (7.7%) were freshman. When disaggregating by average grade across all science courses taken, eighty-six (51.2%) earned an A average, fifty-nine (35.1%) earned a B average, twelve (7.1%) earned a C average, four (2.4%) earned a D average, and two (1.2%) earned a F average.

### Schools

There were two types of high schools involved in this study, career and technical high schools and comprehensive high schools. Career and technical high schools are facilities that students attend for only part of the day to take vocational courses. The student body often is restricted to juniors and seniors. The schools that fit into this category were Huntsville Center for Technology, Madison County Career Academy, Earnest Pruet Center of Technology, and Walker County Center of Technology. All of these schools are located around the Huntsville, Alabama metropolitan area. The types of classes surveyed at these schools were computer, drafting, machine shop, welding, and electronics. The courses involved in HUNCH activities at the schools are listed in Table 6.

Table 6. Courses That Incorporate HUNCH Activities

<i>STEM Course</i>	<i>Number of Individual Participants</i>
Engineering	16
Precision Machine Shop	47
Manufacturing	3
Electronics	6
Computer Electronics	4
Drafting	19
Auto Body	12
Computers	12
Welding	17

Table 6 Continued

---

Elective HUNCH class	16
Not yet participating in HUNCH	17
Total Participants	169

---

Comprehensive high schools included a student body that allowed ninth through twelfth graders to participate in HUNCH. These participating schools were Lincoln County High School in Fayetteville, Tennessee; Clear Creek High School in League City, Texas; Cypress Ranch High School in Cypress, Texas; Cypress Woods High School in Cypress, Texas; and Laurel High School in Laurel, Montana. The types of classes surveyed at these schools were engineering, manufacturing, machine shop, electronics, physics, and HUNCH classes.

This research involved visiting nine different schools in four different states (see Appendix D). NASA officials selected the schools that the researcher visited. The selection criteria involved the type of work that the school did for HUNCH. Schools needed to be building and designing scientific hardware for HUNCH. Selection also involved location and time limitations as the researcher could only visit a limited number of schools during a two-week trip. Schools were all located within a one-hundred mile radius of either JSC or MSFC, except for Laurel High School in Laurel, MT.

Some teachers enlisted their entire class on HUNCH projects, while others only involved selected students who participated because of their interests and abilities. Usually students did not know they were going to be involved with projects for NASA

when they entered their STEM classes. For example, in a drafting class of twenty students, only four of the students worked on HUNCH projects. These students were volunteers and had particularly good skills and interests in drafting and or NASA. These students did not know about HUNCH projects until after enrolling in the class. Some HUNCH students each year were selected to be interns during the summer working on HUNCH projects at JSC or MSFC. These were the only students who received a stipend for their work. All of the STEM HUNCH classes in this study received elective credit.

Only Laurel High School classes worked full time on HUNCH projects. These students selected the HUNCH class. All of the other schools incorporated HUNCH projects into their curricula throughout the school year. Classes varied as to how much time they devoted to HUNCH projects. HUNCH projects, in all the classes, helped to meet the National Council of Mathematics or Science standard-based requirements of applying meaningful learning to skills acquisitions.

The following section describes the nine high schools which are involved in this study. When this study was taken in March 2009 there were about 20 schools involved in HUNCH. The following schools were selected for this study by NASA HUNCH officials, because each school worked on STEM projects and were within a reasonable distance for travel. Some HUNCH schools are a greater distance than an hour travel from JSC or MSFC and some were tasked with the construction of cargo stowage bags for NASA, which did not meet the researcher's criteria for schools involved in STEM projects.

It is important, however, to keep in mind that each school does approach HUNCH projects according to their own design. The HUNCH program itself is open ended to

allow schools the opportunity to adapt the program in the best way possible for its students. The following section will describe each school involved in this research. This information is also reported in Table 7.

Table 7. Listing of Schools in the HUNCH Program and the Number of Years That They Have Been Participating

School	Location	Setting	Reduced and Free lunches	# of boys and girls	Year Built	Number of years in HUNCH	Type of School
Clear Creek High School	League City, Texas	Urban	20.95%	2100	2004	6	Comprehensive
Cypress Woods High School	Cypress, Texas	Suburban	11.3%	3160	2003	3	Comprehensive
Cypress Ranch High School	Cypress, Texas	Suburban	7.9%	1508	2008	1	Comprehensive
Lincoln County High School	Fayetteville, Tennessee	Rural	35%	1150	1979	5	Comprehensive
Laurel High School	Laurel, Montana	Rural	14%	600	1963	4	Comprehensive
Huntsville Center For Technology	Huntsville, Alabama	Urban	50.25%	500	1970	6	Vocational
Earnest Pruet Center of Technology	Hollywood, Alabama	Rural	71.50%	460	1972	4	Vocational
Madison County Career Academy	Madison, Alabama	Rural	34.5%	400	1970	1	Vocational
Walker County Career and Technology Center	Jasper, Alabama		29%	545	1973	<1	Vocational

Clear Creek High School. Clear Creek High School is a progressive school that is committed to promoting the following mission: **Courage, Collaboration, Innovation, and Self-Direction** to equip students with the ability to succeed in the 21<sup>st</sup> Century (“Mission Statement,” n.d., para 1). Because of this mission and the school’s location close to JSC, Clear Creek High School was a perfect choice to become one of the first schools involved in the HUNCH project.

Many of the students’ parents work for NASA. This causes the educational level of the students’ parents to be higher than average. The students are familiar with engineers and their occupations. The students have visited JSC many times, either with their family or school. The school is predominately white with a higher social economic status than most schools in the Houston area.

Clear Creek High School entered the HUNCH program in 2003, under the direction of Gibbs, by opening up their machine shop that had previously been closed due to the lack of student interest for several years (W. Gibbs, personal communication, March 10, 2009). When the HUNCH project started, NASA provided used surplus equipment from JSC for the school’s machine shop. Student enrollment in machine shop escalated rapidly each year as word spread that the machine shop students were working on projects for NASA (S. Hale, personal communication, March 10, 2009). One young female student whose Mom worked for NASA transferred to Clear Creek High School just to be in the HUNCH program.

Clear Creek High School is a comprehensive high school allowing for all grades to participate in HUNCH activities. Gibbs, the Machine Shop instructor explained that in

machine shop, HUNCH projects are chosen according to the experience of the students. The 3<sup>rd</sup> and 4<sup>th</sup> year students work on the most challenging experiments, but there are also projects for freshman and sophomores who are enrolled in machine shop 1 (W. Gibbs, personal communication, March 10, 2009).

The machine shop and the engineering students work together on HUNCH projects. The engineering students do the drafting and designing of the HUNCH projects and the machine shop students do the fabrication. Together they have built single stowage lockers, glove boxes, shelves, refrigerator/freezers and many more components to help train the astronauts for life on the ISS. Over the past three years, the engineering and machine shop classes combined their skills to design and fabricate a dining table proposed for astronauts use onboard the ISS. Gibbs indicated that the table never made it to the ISS, because a new crew of astronauts came onboard the ISS, and they decided that they already had sufficient dining tables. However, the table and some students had the incredible opportunity to fly onboard the zero gravity plane at JSC (W. Gibbs, personal communication, March 10, 2009).

The school's involvement in the HUNCH program is widely publicized in the school and community and they are very proud of their work. The local media has run numerous stories about the students' work for HUNCH and the articles are displayed on the classrooms' walls. The students' ride on the zero gravity plane received national media coverage. This school is considered a model HUNCH comprehensive school facility.



Huntsville Center for Technology. Huntsville Center for Technology is a progressive technical school whose mission is to instill the love of learning into their students so that they become lifelong learners (<http://www.hsv.k12.al.us/mission.php>). These students live in Huntsville, Alabama the home of Marshall Space Flight Center. However, these students come from moderate income families (57% free lunch recipients) The school is predominantly African American (100%) (<http://greatschools.org/cgi-bin/al/other/755#students>).

Huntsville Center for Technology entered the HUNCH program in 2003. From the very beginning, the HUNCH activities were designed to integrate across as many curricula as possible. Therefore, the precision machine shop, electrical technology class, carpentry shop, drafting design class, auto repair shop, and computer electronics class all worked together on HUNCH projects. Ed Turner, the principal realized that the HUNCH program would be a great way to get teachers working and communicating together (E. Turner, personal communication, March 16, 2009).

Zeek, HUNCH manager for MSFC, indicated that over the years, these students have built high quality training hardware for NASA (B. Zeek, personal communication, March 16, 2009). At Huntsville Center for Technology, students work with cutting edge machinery such as Computer Numeric Control (CNC) machines. Graduating students are often professionally certified in their major field of study (Huntsville City Schools, 2009-2010).

Turner, the school's principal is extremely involved with the day to day activities of his teachers and students. He is very enthusiastic about the HUNCH program and over

the years HUNCH activities have become a major part of their school's curricula (E. Turner, personal communication, March 16, 2009). They are so proud of their HUNCH work that the main entrance has numerous poster sized pictures on its walls of examples of what they have fabricated for NASA. Their principal has been able to incorporate HUNCH activities into almost all of the school's curricula.

The following descriptions are of the remaining seven HUNCH schools in this study. Each school in this study has unique characteristics. There are 4 comprehensive schools and 3 technical schools described below.

Cypress Woods High School. Cypress Woods High School is a comprehensive school about an hour outside of Houston and JSC. It is located in a rapidly developing suburban area and has 3160 students in grades 9-12. The school is relatively new since it was built in 2006. The school is predominantly white (62.6%) and only 13.5% of its students receive free lunches ("Demographics," 2009-2010).

Like Clear Creek High School only two teachers have been involved in the HUNCH program. The drafting teacher's class does the designing and the industrial machine shop students do the fabrication. A traveling mock-up trailer of the Destiny Lab onboard the ISS is the main project of the school. The trailer is designed to travel from school to school, allowing students to get a feel for the Destiny Lab as they stroll through the trailer. Hale, the HUNCH Project Manager, indicated that Cypress Woods High School has been constructing this trailer since 2008 and it will be finished by the end of the 2009-2010 school year (S. Hale, personal communication, March 15, 2010).

Cypress Ranch High School. Cypress Ranch High School is in the same Texas school district as Cypress Woods High School. The school was built in 2008 and has 1508 students. Cypress Ranch High School became involved with HUNCH the school's opening year. The HUNCH program at Cypress Ranch High School is a club that builds electrical circuitry for HUNCH projects. This is the only HUNCH school that participates as a club. The teacher is the instructor for the electronic technology class and the club members come from this class.

Cypress Ranch High School is located in a fast growing community of professionals outside of Houston, within the same community and school district of Cypress Fairbanks Independent School District. Cypress Ranch was built to accommodate the expanding student population of Cypress Woods. Both schools are located within a few miles of each other and have similar demographics.

Lincoln County High School. Lincoln County High School in rural Fayetteville, Tennessee is the farthest HUNCH school from MSFC. The school has 1150 students who come from a community of blue-collar workers. Thirty-five percent of the students receive free or reduced-fee lunches. The mission of the school is to engage each student at his or her own ability levels. The HUNCH project works well with this mission, because the HUNCH teachers incorporate the HUNCH work into the activities for selected students who are interested and capable of accomplishing HUNCH projects' challenging work. The only two classes involved in HUNCH are the drafting and machine class, with only a select handful of students from both classes designing and fabricating projects for HUNCH.

Laurel High School. Laurel High School in rural Laurel, Montana was selected as the first school that is a significant distance from JSC or MSFC to participate in HUNCH. The school has been building electrical hardware for training astronauts since January 2005. The school has 600 students who live in a blue-collar community made up primarily of farmers, railroad workers, and Cenex employees.

The HUNCH program at Laurel High School started as a cooperative effort between the gifted program coordinator and the vocational/agriculture teacher. The HUNCH students are part of the gifted program, however their classroom is in the vocational/agriculture building. The HUNCH students use the tools and equipment in the vocational/agriculture shop. Laurel High School's vocational/agriculture shop has only the very basic tools and does not have CNC machinery or CAD programs, which are needed for HUNCH activities. Without the help of local businesses and engineers, who possess these tools, the HUNCH program at Laurel High School would never have been able to complete their first task, which was to fabricate six standoff interface panels (SIP) that were proposed to be used to train astronauts for the ISS.

The HUNCH program brought a new perspective to the school community. HUNCH students became admired by their peers on par with the football players of the high school. The local news media did numerous articles about the HUNCH students' work and activities. When the students travelled to JSC for the HUNCH Awards Assembly and a VIP tour of JSC, the local TV station and newspapers reported on their travels.

The HUNCH program at Laurel High School is the only HUNCH school that uses HUNCH activities as their curriculum. Students enroll in the HUNCH class as many times as they wish for an elective credit each school year. At the end of the 2009-2010 school year, one female HUNCH student was the first student to participate in HUNCH every semester of her high school years. Both the teachers and selected students have spent a week at JSC training to be flight certified in harness making and crimping.

Madison County Career Academy. Madison County Career Academy was built in 1970 with the mission to provide hands-on learning to its students. The school is located in rural Madison County, Alabama and its students come from the county high schools to take vocational technical courses. This school is not your typical HUNCH vocational school because only a single class of five drafting students is involved in HUNCH. HUNCH officials plan to involve other classes throughout the school in future years. As with other career centers, this school has the capabilities to design the projects in drafting class and then incorporate the construction of the projects into many of their curricula.

Walker County Career and Technology School. Walker County Career and Technology School has only been involved in HUNCH for less than a year. At the time of this study, only a few students in electronics class are working on a HUNCH project. However, it is planned that the HUNCH project will integrate across many curricula offered at the school, such as drafting, auto collision, carpentry, and machine shop. Each class of students will contribute their expertise to the fabrication of the HUNCH project.

Earnest Pruet Center for Technology (EPCOT). EPCOT has a reputation of being one of the best career/technical schools in the nation. Their classrooms are equipped with the state of the art machinery, much of which is donated by industrial companies in the area. The school is located on 40 acres of land in rural Alabama. The students who attend come from eight different feeder schools. The students are from 10<sup>th</sup>, 11<sup>th</sup>, and 12<sup>th</sup> grades and only spend half of their school day at EPCOT (“About the School,” n.d., para 3).

EPCOT has been involved in the HUNCH program since the 2005-2006 school year. Their HUNCH projects involve integrating courses from a wide range of curricula areas, such as drafting, machining, auto repair, construction, electricity. Their main project has been the construction of a road worthy trailer that will carry a 3-D printer to HUNCH schools that do not have one. At the time of this study, the trailer is constructed and proposed to be on the road next year.

EPCOT students come from low income families with over 50% receiving free or reduced lunches. The students’ parents were mainly blue-collar workers. The students have minimum exposure to STEM professionals.

### Research Design

This study aims to determine what aspects of the HUNCH program contributed best to motivating student learning in the STEM areas and interest in STEM careers. This study used a mixed-methods approach using both quantitative data from the SIMSQ and qualitative data from focus groups and individual student interviews, to answer the

research questions posed for this study. In addition, this research investigated the learning experiences that best promote students' interest in STEM coursework and careers.

The quantitative component of this study examines students' self-perceptions of science and STEM HUNCH classes by the use of data from the SIMSQ. The qualitative research investigates students' opinions on learning experiences that best promote secondary students' interest in STEM coursework and careers. This data is collected from student focus groups and individual student interviews.

The independent variable is student involvement in the HUNCH program. This variable is broken into the following two groups: students who have little exposure in HUNCH classes and students that have participated in HUNCH classes for three semesters or more. The rationale behind this division is that a one-year period is necessary for students' perceptions to be altered by HUNCH activities, as was indicated by the data analysis examining student responses for each semester in HUNCH. Results from the first two semesters in HUNCH did not show any differences.

### Data Collection Instruments

#### Introduction

This study uses a mixed-method approach that involved data collection via the *Student Interests and Motivation in Science Questionnaire* (SIMSQ), focus groups, and individual student interviews involving 169 students from nine schools. One college student, who participated in HUNCH while in high school, was also interviewed. The

researcher was particularly interested in learning from the participants about how the HUNCH program influenced their motivation to study and pursue careers in STEM areas.

### Study Fidelity

The famous quote by Einstein, “Everything that can be counted does not necessarily count: everything that counts cannot necessarily be counted,” (Mayan, 2009, p. 9) helps to explain why both quantitative and qualitative data were vital to this study. This study is about educational practices that form a complex multi-faceted issue. Numbers alone cannot tell the whole story. Better insight into the understanding of the numbers can only be obtained by qualitative inquiry. While the quantitative data analysis adds objectivity to the study, the qualitative analysis expands the insightfulness of the study. In a qualitative study, the participants’ perspective allows a holistic picture to form. A mixed-method approach produces a synergy that is more than the sum of its parts.

Advantages of quantitative data are different from qualitative data. Quantitative data allows for the collection of data from large numbers of participants. In addition, other researchers can easily accomplish the replication of this data collection. However, the analysis is limited to those constructs on the SIMSQ. The advantages of qualitative data is that it allows for an in-depth look at the findings, which provides a much richer, more diverse, picture of participants’ perceptions. Qualitative data analysis takes an inductive approach to theorizing the results, which allow new motivational constructs to emerge.



### Student Interests and Motivation in Science Questionnaire (SIMSQ)

Numerous questionnaires to survey self-perception of academic motivation exist, but only one questionnaire was found in the literature that was specifically designed to measure student motivation in science. This SIMSQ (Appendix H) was developed by Ghahi Hassan (2008) at the University of Western Sydney, Australia, and was selected by the researcher due to its relevance in evaluating the HUNCH program.

The SIMSQ provides insight into the following seven constructs involved in motivating students to study and pursue careers in science: enjoyment of science, self-concept of ability in science, lack of anxiety in science classes, ability to make choices in science classes, interest in science, usefulness of science, and career interest in science. These seven constructs are the dependent variables of this study.

As part of the SIMSQ administration students were asked to record the gender, science grade point average, number of science courses taken in high school, grade level, and the number of semesters the students participated in HUNCH. Students who indicated zero, one, or two semesters of HUNCH are classified together in the group labeled new to HUNCH. The other classification, experienced in HUNCH, are students who have taken three or more semesters of HUNCH. This means that these students have had at least one full year of HUNCH.

Students answered 35 questions in the SIMSQ (Appendix H) using a five point Likert scale regarding their perceptions about science and science classes. The Likert scale used was as follows: Always = 1, Often = 2, Sometimes = 3, Seldom = 4, and Never = 5. Questions 2-9, 14-31, 33, and 34 were reverse scored.

Two important statistical analyses of any questionnaire are the reliability and face validity of the instrument. Hassan measured the reliability of the SIMSQ using Cronbach's alpha, which yielded a coefficient value of 0.88. A value of 0.88 indicates good reliability, since it is above the standard Cronbach's alpha value of 0.80 (Gravetter & Wallnau, 2007). The researcher accessed good face validity for the SIMSQ since this study's questions related directly to the motivational constructs measured. Table 8 provides a list of the questions representing each construct and the research question that it addresses.

Table 8: Table of Specifications of Questionnaire: Seven Constructs of Student Motivation in Science Classes

Construct	Construct Questionnaire Number	Research Question Addressed
Enjoyment of science	1, 2, 3, 4, 5, 6	1,3,4
Self-Concept of ability in science class	7, 8, 9	1,3,4
Lack of anxiety in science class	10, 11, 12, 13	1,3,4
Ability to make choices in science class	14, 15, 16, 17, 18	1,3,4
Interest in science	19, 20, 21, 22, 23, 24, 25, 26	1,3,4
Usefulness of science	27, 28, 29, 30	1,3,4
Career interest in science	31, 32, 33, 34, 35	2

### Focus Groups

An advantage of a mixed-method study is to be able to triangulate data. Therefore, most of the focus group questions deal with the same seven constructs on motivation found in the SIMSQ. However, to better answer research question 3, some of the focus group questions deal directly with the HUNCH program's motivational practices and learning experiences. Appendix E lists the focus groups questions. Initially,

a single student answered the question, but when he or she was through, other students commented on the question. This allowed for group dynamics and interactions to aid discussions. Students were able to opt out of answering any question at their own discretion. The teachers were free to join the focus groups. All of the focus groups were recorded using a digital audio recorder.

Focus group validity is concerned with the truthfulness of its findings. The use of memoing, which is writing analytical notes on the data and coding of the transcribed recordings facilitated the theorization of what was actually expressed by the participants. To insure this validity the researcher vigorously applied reflective thinking to prevent personal biases from influencing the findings. The generalizability or external validity of the focus groups does not extend to other types of participant populations. However, the knowledge that is generated by the focus groups can be generalized (Mayan, 2009). Knowledge generalizability is an important aspect of qualitative research, which extends the external validity of mixed-method studies.

Reliability for focus groups comes about by repetition of themes within the data collection process (Mayan, 2009). For example, if students repeatedly mention the motivational construct of doing hands-on work then the reliability of hands-on work is increased each time it is mentioned. In this study, the repetitive themes are noted.

### Stakeholder Interviews

Individual student interviews in this study were open-ended and conversational because of the need to make each interview fit the interviewee and allow for maximum freedom of discussion. Appendix E lists some guiding questions that are differentiated for

students. The lengths of the interviews were dependent on the availability of the interviewee.

The validity of the interviews was premised on accurately representing what the interviewee was expressing. Repeating what the participant said was used to provide evidence of the validity of the interview results. The interviewer would often repeat what the interviewee said to verify that the interviewer understood their comments. This was also done during the focus groups and had the added purpose to allow the transcriber to better hear students' comments. Only the student interviews are reported in this research; however teachers, principals, and NASA officials were interviewed for added validity to what the students were indicating. The only one doing data analysis on the qualitative data is the researcher; there is no inter-rater reliability. The reliability of the interviews can be measured by the clarity and careful dynamics that existed between the interviewer and interviewee. Efforts to insure reliability of interviews were established by the interviewer listening carefully and not allowing her personal biases to influence the interviewees' responses.

### Procedures

The researcher arranged school visits by emailing and/or telephoning principals of the selected schools in order to gain permission to conduct the research and contact their teachers (Appendix F). After receiving the principal's consent, emails and telephone calls went out to teachers in order to obtain their permission and organize a time schedule for visitations. Teachers handed out consent forms to students prior to the researcher's visit

so that the researcher could begin the data collection upon arrival (Appendix G). The NASA officials involved with HUNCH accompanied the researcher to the schools.

Upon arrival in a classroom, the researcher first explained the goals of the research to the students. The researcher explained that she was there to learn from them, and to listen to their ideas as to what best motivates them to study and pursue careers in STEM areas. The researcher found that a good introduction about the purpose of the research led to the best student involvement in the focus groups. Consent forms were collected from the students. Only students who handed in a consent form were permitted to participate in the questionnaire and focus groups. The teachers arranged activities for students who did not have consent forms.

While the students completed the questionnaire, the researcher assigned identification code numbers to the students so that names were not placed on the questionnaires. This procedure served to maintain confidentiality of the participants. The students were informed that their participation was voluntary and would not influence their grades. Only the researcher would have access to their identification code numbers.

From a previous pilot study, the researcher knew that questionnaires took between five and ten minutes for students to complete. Students were to use their HUNCH class in place of the science class specified on the SIMSQ. The researcher told the students to feel free to inquire if they were confused about a question. The researcher also encouraged students to write comments if they wanted to further explain their responses.

Upon completion of the SIMSQ, students were given the choice of having a focus group or individual interviews. All the classes chose focus groups. Engaging students in

the focus groups involved the following activity. Students drew pieces of paper from a small, cloth, black bag. The pieces of paper had questions from Appendix E written on them. All students received a piece of candy at the end of the focus group activity. Focus groups lasted from twenty minutes to an hour, and were dependent on the school's time schedule. The questions for the different focus groups varied slightly as the researcher continually readjusted the questions to better fit the research. This was accomplished by removing or adding new questions to the black bag.

Following the focus groups, individual student interviews were conducted with participants who were willing to be interviewed and available. The interviews were of the open-ended conversational type with the interview questions in Appendix E as guides. Interviews lasted from fifteen minutes to an hour dependent on the interviewee's availability.

Individual student interviews took place primarily at schools. The goals of the interviews were to learn as much as possible about how students perceive STEM coursework and careers. In addition, the researcher wanted to learn what learning experiences in HUNCH classes motivated students to study and pursue careers in STEM areas. An Olympus DS-40 digital stereo voice recorder recorded the interviews and focus groups.

## Data Analysis

### Questionnaires

Results from the questionnaires were analyzed to measure the degree in which each construct influenced student motivation to study and pursue careers in science. The results were entered into the Statistical Package for Social Sciences (SPSS). The statistical analysis best suited for analyzing data from the SIMSQ is the Multivariate Analysis of Variance (MANOVA) (Leech, Barrett, & Morgan, 2008). The MANOVA was used because the items for each SIMSQ construct were analyzed simultaneously. The item scales ranged from 1-5 with 5 represented the most favorable perception. SPSS was also used to calculate the percents of the frequency of each of the Likert scale answers to every question along with other descriptive statistics.

### Analysis of Focus Groups and Interviews

The digital recordings from the focus groups and individual student interviews were transcribed in order to obtain a readable description of the data. However, the researcher also listened to all the digital recordings multiple times. There were many hours of interviews of the NASA HUNCH directors, HUNCH teachers and principals, to assure the researcher obtained an informed perspective of HUNCH activities.

Memoing, which is writing analytical notes on the data that helps the researcher ask “why” the data was collected, was the first step in analyzing the qualitative data. The data was then coded into themes that were important to this study. Public Comment Analysis Toolkit (PCAT) beta software was employed. This software allowed the

researcher to write analytic memos, code key concepts, obtain organized summaries, and validate coding by a comparison with another coder. Constant code-recode procedures were used to determine conceptually similar themes (Corbin & Strauss, 2008). Finally, theorizing, which is similar to inductive reasoning, was applied to summarize the individual themes of the data into emergent themes (Mayan, 2009). These qualitative analyses involved not only coding data into the seven constructs, but also into any new themes that emerged.

### Trustworthiness of Qualitative Research

Guba and Lincoln proposed in 1985 to use the term trustworthiness as a measure of rigor of qualitative research (Mayan, 2009). The Guba and Lincoln model uses four strategies to determine trustworthiness, which are credibility, transferability, dependability, and confirmability (Mayan, 2009).

Credibility is similar to internal validity in quantitative research. Credibility assesses the accuracy of the results. In this study, interviewing teachers and NASA officials was employed to obtain all points of view. This involved detailed discussions with the NASA HUNCH directors, HUNCH teachers, and principals at some of the schools involved in this research. In addition, the researcher wrote her immediate impressions of student comments daily in a journal. The journal contains a record of the researcher's reflections on the day's data collection. Finally, the use of methodological triangulation by the mixed-methods approach increased the internal validity of both the qualitative and quantitative results (Creswell, 2002).



Transferability is similar to external validity in quantitative research and is defined as the applicability of the research results to other settings (Mayan, 2009). In this study, the only degree of transferability is to settings similar to where the study took place. By providing a detailed description of the participants and their settings, some transferability of results is possible to similar environments.

Dependability is similar to reliability in quantitative research. In quantitative research, the replication of a study is facilitated by replication of surveys or questionnaires. However, in qualitative research this is not possible. There can be replication of focus groups or interview questions; however, because of the variability within group dynamics, exact replication of activities is impossible. Nevertheless, the occurrence of the same theme in data gathered from different participants adds reliability to qualitative results. In this study, themes emerged when participants repeatedly presented the same comments or answers to a question. Code-recode procedures in which the researcher constantly compared results within and between focus groups and interviews added to the dependability of the research. Comparing student perspectives was used in order to find emergent themes. Student perspectives were compared for similarities and differences. Perspectives that were conceptually similar were grouped together to form themes (Corbin & Strauss, 2008). In addition, the triangulation of the data from the SIMSQ, focus groups, and individual student interviews helped to authenticate the dependability of the results.

The last strategy to determine trustworthiness is confirmability. Confirmability is similar to objectivity in quantitative research (Mayan, 2009). By its very nature, of

qualitative research depends on researchers to reflect on their biases and to understand how the researcher's perspective influences the objectivity of the study. No study, whether quantitative or qualitative, is totally objective in nature. It is the responsibility of the researcher to know his or her personal biases and minimize their influence on the data collection and analysis (Mayan, 2009). It is vital that when the researcher is managing the focus groups and interviews she does not express her opinions. As stated earlier in this chapter, the researcher was there to listen and learn from the students and not the other way around. The researcher worked conscientiously at controlling her reactions to students' comments so that participants were not influenced by any evaluative responses by the researcher. In addition, triangulation of the methods helps to add confirmability to this study.

In summary, the trustworthiness of qualitative research depends on using data collection and analysis procedures that allow for the triangulation necessary to support the dependability, credibility and confirmability of the results. The use of the mixed-method approach allows for methodological triangulation, which provides evidence to support the credibility, confirmability of the study (Mayan, 2009). Triangulation of the results from the SIMSQ, focus groups, and individual student interviews increased the dependability of the findings by comparing the results from these three sources (Mayan, 2009).

### Potential Limitations of the Study

Limitations of any study involve error associated with the data collection and analysis. This study collected data from the Student Interests and Motivation in Science Questionnaire, interviews, and focus groups that all possess some inherent form of inadequacies or degrees of errors. The self-report nature of the SIMSQ is a source of error, because participants may or may not be answering all of the questions honestly. Even though Hassan (2008) tested SIMSQ for reliability and validity, there is always the possibility that students may misread or misunderstand the intent of a question. One further caution on the SIMSQ is that Hassan (2008) developed the questionnaire for Australian, not American students.

Interviews and focus groups add their own source of limitations to this research. The open-ended conversational style of interviewing is limited in the fact that the interviewees are not all asked the exact same questions. This can lead to inconsistencies in the data collected. A drawback of focus groups involved peer pressure, which can affect the discussion in any focus group, but especially in groups of teenagers. Time limitations existed with all of the interviews and focus groups. Because of the dependency on the school schedule of the interviewees and participants of the focus groups, there were situations where there was not enough time to complete the discussions.

Time was a limitation of the data collection process. Most of the data collection occurred within a two-week period. Because of this time limitation, most of the participants were enrolled in HUNCH for various periods. It would have been ideal if the

study had occurred over a longer period so that participants could have been questioned before and after they were enrolled in HUNCH. Thus, for comparison purposes, this research examines students who were enrolled in HUNCH for varying periods on a continuous scale from just beginning to four semesters or more in HUNCH.

Data analysis provides its own limitations for both quantitative and qualitative data. In this study, the quantitative data was analyzed using descriptive and parametric statistics. Descriptive statistics are limited to providing the big picture derived solely from student responses on the questionnaire. The use of the parametric MANOVA tests provided insight into the group student responses on the questionnaire; this analysis was still limited to the questions asked on the questionnaire. Results from the qualitative data analysis are influenced by the ability of the researcher to understand and report the data as objectively as possible.

### Researcher Perspective

Any research, whether quantitative or qualitative, is not void of the researcher's perspective. There is no such thing as completely objective research. Research is always reflective in various degrees of the researcher's views (Mayan, 2009). It is up to the researcher to make the study as objective as possible by providing rigor, reflexivity, analytical, and critical thinking, along with an awareness of his or her own biases. Therefore, it is imperative that researchers provide information about their own experiences, which may influence their perspectives on a study. Below I will describe my experiences with the HUNCH program.

Never in my fondest dreams did I imagine that someday my high school students and I would be working on NASA projects. I always believed that space exploration would play a key role in the future well being of humankind, but I never thought I would be directly involved in this endeavor. However, for the last three years of my teaching career at Laurel High School, I was the teacher/facilitator for the HUNCH program. Involvement in this program was so beneficial to the students, school, and the community of Laurel that I began to question why more programs like HUNCH did not exist.

I witnessed life-changing attitudes in my students that were a direct result of their amazing accomplishments in the HUNCH classroom. Students who disliked school and especially disliked their mathematics and science classes learned firsthand the value of science and mathematical skills as they applied them to the HUNCH projects. These activities resulted in a transformation in their attitudes toward school, and in particular to their mathematics and science courses.

My objective in doing this study was to take a close look at exactly why and how the HUNCH program motivates students to study and pursue careers in STEM areas, in hopes that it can be used as a framework in building such programs across the nation. Thomas Friedman (2005) writes about the “quiet crisis” in which the number of American students in STEM areas is on the decline. This study seeks to stop this “quiet crisis” by changing the paradigm that exists in today’s STEM courses. Finding the best directions for this paradigm shift to succeed is what this study is ultimately all about.

As a direct result of my HUNCH teaching and doctoral work, I have now joined the HUNCH team as the HUNCH National Laboratory Project Manager. In this position,

I help schools across the country get involved in applied scientific experiments. The HUNCH National Laboratory program seeks to have high school students design, document, and fabricate experiments proposed to fly onboard the International Space Station. It is my job to supply the students with information, materials, resources, mentors and anything else they may need to successfully fabricate their experiments. Because of my involvement as a HUNCH teacher, I entered this research from a positive perspective.

### Summary

This chapter begins with a description of the participants and schools involved in the HUNCH program to provide an in-depth understanding of the context of this study. This section is followed by a description of the mixed-methods design undertaken to answer the researched questions posed for this study. The data was collected by the researcher administering the SIMSQ questionnaire, focus groups and individual student interviews. Following the questionnaire, students participated in focus groups that consisted of questions about their experiences in HUNCH STEM classes and their opinions of what motivates them to study and pursue careers in STEM areas. Teachers recommended individual students to be interviewed. These students had to be available for interviews that lasted from 10 to 30 minutes.

The quality of the analysis was substantiated in the sections describing study fidelity and trustworthiness. The advantage of the mixed-method approach for this study was the use of triangulation to support the study's trustworthiness. Finally, the

researcher's perspective is discussed to inform the reader of the researcher's experience with the HUNCH program, and the lens through which she views school-based STEM HUNCH classes.

## CHAPTER FOUR

## RESULTS OF THIS STUDY

Introduction

This chapter reports the results from the Student Interests and Motivation in Science Questionnaire (SIMSQ) and the qualitative findings from student focus groups and interviews as they relate to the four research questions posed by this study. Each question will be examined in detail, followed by a comprehensive synthesis of the quantitative and qualitative results. The research questions' results reported in this chapter are as follows:

- (1) How do students who participate in HUNCH programs perceive STEM HUNCH courses and other STEM courses?
- (2) How do students who participate in HUNCH programs perceive STEM related careers?
- (3) What learning experiences do HUNCH students describe as motivating them toward pursuing courses and careers in STEM areas?
- (4) Do students who have fewer than two semesters in HUNCH perceive STEM courses and careers differently than students who have participated in three or more semesters in HUNCH?

The SIMSQ was designed by Hassan (2008) to survey students about their perceptions of science classes. However, in this research students were asked to substitute their STEM HUNCH classes for all questions on the SIMSQ that read “this science class.” For example, question number 13 asked, “How often does this science class make you feel unhappy? Students were asked to substitute



“How often does this HUNCH class make you feel unhappy?” The reasoning behind this change was that the students participating in this study did not come from science classes but from their STEM HUNCH classes. The researcher wanted to study students’ perception of their STEM HUNCH classes as well as their interest in science and their regular science classes. This change in questions was written on the top of the questionnaires and the researcher explained these changes verbally to the students. With this change, the SIMSQ then posed questions about student perceptions of STEM HUNCH classes, science interest, and science classes. In specific questions 7-18 asked students about their STEM HUNCH classes, questions 5, 19-26, and 31-35 asked students about students’ perceptions of their interest in science, and questions 1-4, 6, and 27-30 surveyed students’ perceptions of science classes. Students were involved in a variety of vocational coursework that incorporated HUNCH activities. The list of courses and the number of student participants is found in Table 6.

The focus groups and interviews were made up of students that were enrolled in STEM HUNCH courses, across nine schools. There were two types of high schools that participated in the HUNCH program. One type was the comprehensive high schools, in which students were enrolled in STEM HUNCH courses at the same physical location that they took all of their required courses (Table 6). The other type of high school was the career and technology centers or vocational schools, where students only went for part of the day. These centers offered students the courses listed in Table 6, along with many more vocational technical courses. However, they took all their required courses at

their “home” school and therefore had to travel each day between the career and technology centers and their home schools. Table 9 lists the schools and the STEM courses in which HUNCH projects are incorporated. The number of HUNCH teachers, what the classes fabricated and how many students were involved in HUNCH is also listed in Table 9.

Table 9. HUNCH Schools and Project Information

High Schools	HUNCH Courses	Number of HUNCH Teachers	Fabricating	Number of Students
Clear Creek	Engineering, Machine Shop I and II	2	Wardroom Dining table and single stowage lockers	45
Cypress Woods	Drafting, Machine Shop	2	Mock up Destiny Lab Trailer	15
Cypress Ranch	Electronics	1	Electronic circuit board	4
Lincoln County	Machine Shop, CAD Drafting, Welding, Sewing	4	Standoff Interface Panels, Cargo Transfer Bags	22
Laurel	Gifted Program and Vocational agriculture	2	Standoff Interface Panels	21
Huntsville Center For Technology	Drafting, Computer Electronics, Precision Machine, and Painting/etching	4	ISS simulation for training Lab, ISS lockers, Website Developer/Simulator, EXPRESS brackets, ISS racks	29

Table 9 Continued

Earnest Pruet Center of Technology	Welding, Electronics, Precision Machine, Drafting, Painting, Carpentry	7	Design and fabrication of trailer to carry Robot and 3D printer, ISS simulation for training Lab	48
Madison County CTC	Drafting	1	Portable glove box	5
Walker County CTC	Drafting, Computer Electronics, Welding, Graphic Arts, Collision Repair	7	I/O Relay Switches, trailer for HUNCH Robot	42

---

Research Question 1: How do Students Who Participate in HUNCH Programs Perceive STEM Courses?

Introduction

Research question 1 was answered from student responses to questions 1-30 of the SIMSQ survey (Appendix H), the results from student focus groups, and individual student interviews. The SIMSQ survey's questions are divided into seven constructs: enjoyment of science classes, self-concept of science abilities, lack of anxiety toward science classes, abilities of students to have choices in science classes, interests in science, usefulness of science classes, and career interest in science. Students were instructed to replace the words "this science class" with their STEM HUNCH class in order to connect the results with students' STEM classes that participated in HUNCH

activities. The data from the SIMSQ is presented in tables that are divided into these seven constructs. The tables can be found in the sub-sections that follow.

There were nine schools that participated in this research. Laurel High School, Clear Springs High School, Cypress Woods High School, Cypress Ranch High School, Lincoln High School, Huntsville Center For Technology, Earnest Pruettt Center of Technology, Madison County Technical Academy, and Walker County Center of Technology. Laurel High School's focus group's results were not reported in the qualitative results, because the researcher had previously been many of the students' HUNCH teacher. The researcher felt this fact influenced their focus group's results, so the results were disregarded.

The analysis of all three sources of data from surveys, focus groups, and interviews allows for an in-depth view of student perceptions and emergent themes on how HUNCH students perceive their STEM courses. In this section, the results from the SIMSQ will be presented first, followed by the focus group and interview results.

#### Analysis of SIMSQ Results

Students were asked to rate their perceptions of each question based on the following Likert scale descriptors: Always = 1, Often =2, Sometimes = 3, Seldom = 4, Never = 5. The Likert scale was based on a scale of 1-5, with 5 being the best possible perception of STEM coursework. A score of 1 indicates a poor perception of STEM coursework. Questions 2-9, 14-31, 33, and 34 were reverse scored so that questions were consistent in assessing positive and negative perceptions. This consistency is important to

allow SMISQ scores to be aggregated and interpreted as the higher the total score the more positive the perceptions of STEM coursework.

Enjoyment of Science Classes. The questions in the SIMSQ survey that specifically dealt with HUNCH student perceptions with regard to the enjoyment of science classes were questions 1-6. Table 10 specifies the percentages of student responses for each of the Likert scale choices for these questions.

According to the results in Table 10, 64.2 % of HUNCH students said science classes are *always* or *often* fun and 78.2 % said science classes are *always* or *often* interesting. More than half (59.6 %) of HUNCH students said they *seldom* or *never* are bored in science classes.

Table 10. Percent of Frequency Results for Enjoyment of Science Classes by HUNCH Students.

<i>Student Perception of Enjoyment of Science Classes</i>	<i>Always 1</i>	<i>Often 2</i>	<i>Sometimes 3</i>	<i>Seldom 4</i>	<i>Never 5</i>
1. How often are science classes boring?	1.3%	5.3%	33.8%	47.0%	12.6%
2. * How often are science classes fun?	18.5%	45.7%	30.5%	4.6%	0.7%
3. * How often are science classes interesting?	33.8%	44.4%	19.2%	2.0%	0.7%
4. * How often do you like to go to science class?	34.8%	34.1%	19.3%	7.4%	4.4%
5. * How often does science class make you curious?	23.8%	48.3%	23.8%	2.6%	1.3%
6. * How often do you enjoy science laboratory work?	18.5%	45.7%	30.5%	4.6%	0.7%

*Note.* \* Indicates question was reverse scored

Self-Concept of Abilities in STEM HUNCH Classes. The questions in the SIMSQ survey that specifically dealt with HUNCH student perceptions of their self-concept of abilities in STEM HUNCH classes were questions 7-9. All of the questions in this SIMSQ dimension were reverse scored. Table 11 specifies the percentages of student responses for each of the Likert scale choices for these questions.

The results reported in Table 11 indicate that 78.7 % of students said that their HUNCH class *always* or *often* made them feel confident and 82.0% of them said that their HUNCH class *always* or *often* made them feel successful. Interestingly, 80.2 % of HUNCH students said that their work in class was *never*, *seldom*, or *sometimes* too easy for them, with sometimes representing 56.3% of participant responses.

Table 11. Percent of Frequency Results for Self-Concept of Abilities in STEM HUNCH Classes by HUNCH Students.

<i>Self-Concept of Abilities in STEM HUNCH classes</i>	<i>Always (1)</i>	<i>Often (2)</i>	<i>Sometimes (3)</i>	<i>Seldom (4)</i>	<i>Never (5)</i>
7. * How often have the things you studied in HUNCH class been too easy?	4.6%	15.2%	56.3%	20.5%	3.3%
8. * How often has HUNCH class made you feel confident?	18.7%	60.0%	15.3%	4.0%	2.0%
9. * How often has HUNCH class made you feel successful?	31.3%	50.7%	14.7%	1.3%	2.0%

---

*Note. \* Indicates question was reverse scored*

Lack of Anxiety in STEM HUNCH Classes. The questions in the SIMSQ that specifically dealt with HUNCH student perceptions with regard to their lack of anxiety in

STEM HUNCH classes were questions 10-13. Table 12 reports the percentages of student responses for each of the Likert scale choices for these questions.

The results reported in Table 12 indicated that over 83% of students were *seldom* or *never* uncomfortable in STEM HUNCH class. According to the results in Table 12, a large majority (83.4%) of HUNCH students indicated that their HUNCH classes *seldom* or *never* made them feel unhappy. Less than 3.0% of HUNCH students reported that they were unable to understand the concepts taught in STEM HUNCH courses. Almost 16% of HUNCH students indicated that they *always*, *often*, or *sometimes* felt unable to understand the work in STEM HUNCH class. The remaining 84.1% of HUNCH students indicated that they *seldom* or *never* were unable to understand STEM HUNCH class.

Table 12. Percent of Frequency Results for Lack of Anxiety in STEM HUNCH Classes by HUNCH Students

<i>Lack of Anxiety in STEM HUNCH classes</i>	<i>Always (1)</i>	<i>Often (2)</i>	<i>Sometimes (3)</i>	<i>Seldom (4)</i>	<i>Never (5)</i>
10. How often has HUNCH class made you feel uncomfortable?	2.6%	3.3%	10.6%	31.1%	52.3%
11. How often has HUNCH class made you feel unable to understand?	0.7%	2.0%	13.2%	49.7%	34.4%
12. How often has HUNCH class made you feel stupid?	0.7%	2.6%	6.0%	27.2%	63.3%
13. How often has HUNCH class made you feel unhappy?	1.3%	2.7%	4.0%	24.7%	67.3%

Ability to Make Choices in STEM HUNCH Classes. The questions in the SIMSQ survey that specifically dealt with HUNCH student perceptions with regard to their ability to make choices in STEM HUNCH classes were questions 14-18. Table 13 specifies the percentages of student responses for each of the Likert scale choices for these questions. All of the questions for this SIMSQ dimension were reverse scored.

The results reported in Table 13, show that the most positive perception was expressed for question 17 where over 68% of HUNCH students indicated that they *always* or *often* had the ability to work at their own pace in STEM HUNCH classes. However, a much smaller percent of HUNCH students responded that they *always* or *often* were able to choose topics (29.1%), method of learning (31.2%), and the order of topics (21.9%). Over 60% of HUNCH students felt that they *seldom* or *never* had the chance to decide when to hand in assignments.

Table 13. Percent of Frequency Results for Ability to Make Choices in STEM HUNCH Classes by HUNCH Students

<i>Ability to make choices in STEM HUNCH classes</i>	<i>Always (1)</i>	<i>Often (2)</i>	<i>Sometimes (3)</i>	<i>Seldom (4)</i>	<i>Never (5)</i>
14. * How often have you chosen the topic or project yourself for this HUNCH class?	3.3%	25.8%	37.7%	21.9%	11.3%
15. * How often have you chosen the way you want to learn in this HUNCH class?	9.3%	21.9%	37.1%	20.5%	11.3%
16. * How often have you selected the order in which you study topics in this HUNCH class?	5.3%	16.6%	37.7%	21.2%	19.2%



Table 13 Continued

17. * How often have you had the chance to work at your own pace in this HUNCH class?	34.4%	33.8%	21.9%	4.6%	5.3%
18. * How often have you had the chance to decide when to hand in assignments and take tests in this HUNCH class?	7.4%	11.4%	20.8%	28.9%	31.5%

*Note. \* Indicates question was reverse scored*

Interest in Science. The questions in the SIMSQ survey that specifically dealt with HUNCH student interest in science were questions 19-26. Table 14 specifies the percentages of student responses for each of the Likert scale choices for these questions. All of the questions for this SIMSQ dimension were reverse scored.

Questions 21, 25, and 26 elicited the highest percentage of responses that demonstrated students were engaging in activities indicative of interest in science. 52.9% of HUNCH students responded that they *always* or *often* watched science-related shows on TV, while 54.04% indicated that they *always* or *often* worked on science projects. Approximately half (49.4%) of the HUNCH student respondents *always* or *often* engaged in science related hobbies. A much smaller percentage of HUNCH students indicated that they *always* or *often* read science-related articles in magazines (17.2%) or newspapers (11.3%), went to hear talks on science (12.2%) or read books about science topics (11.9%). However, 32.4% of the HUNCH students completing the SMISQ reported that they *always* or *often* talked with their friends about science projects or worked with science related hobbies.

Table 14. Percent of Frequency Results for Interest in Science by HUNCH Students

<i>Student Perceptions of Interest in Science</i>	<i>Always (1)</i>	<i>Often (2)</i>	<i>Sometimes (3)</i>	<i>Seldom (4)</i>	<i>Never (5)</i>
19. * How often have you read articles on science-related topics in magazines?	3.3%	13.9%	35.8%	27.8%	19.2%
20. * How often have you read articles on science-related topics in newspapers?	3.3%	8.0%	31.3%	35.3%	22.0%
21. * How often have you watched science-related shows on TV?	9.9%	43.0%	31.8%	9.9%	5.3%
22. * How often have you gone to hear people give talks on science?	2.6%	6.6%	27.2%	31.1%	32.5%
23. * How often have you read books about science topics with your friends?	2.0%	9.9%	31.8%	33.8%	22.5%
24. * How often have you talked about science topics with your friends?	8.6%	23.8%	34.4%	23.2%	9.9%
25. * How often have you done science projects?	17.3%	36.7%	32.7%	9.3%	4.0%
26. * How often have you worked with science-related hobbies?	12.7%	36.7%	32.7%	11.3%	6.7%

*Note. \* Indicates question was reverse scored*

Usefulness of Science Classes. The questions in the SIMSQ survey that specifically dealt with HUNCH student perceptions with regard to the relevance of

science classes were questions 27-30. Table 15 specifies the percentage of student responses for each of the Likert scale choices for these questions. All the questions for this SMISQ dimension were reverse scored.

According to the results in Table 15, 76.8 % of HUNCH students said science classes are *always* or *often* useful. However, about one third (32.2 %) of HUNCH students felt that things studied in science classes were *always* or *often* relevant to other school subjects. Approximately 40% felt science classes were *sometimes* relevant to other school subjects. On the other hand over half (51.7%) of HUNCH students felt that things learned in science classes were *always* or *often* useful in everyday life. Less than half (40.7%) of HUNCH students felt that things studied in science classes were *always* or *often* related to things learned outside of school.

Table 15. Percent of Frequency Results for Relevance of Science Classes by HUNCH Students

<i>Student Perceptions of Usefulness of Science Classes</i>	<i>Always 1</i>	<i>Often 2</i>	<i>Sometimes 3</i>	<i>Seldom 4</i>	<i>Never 5</i>
27. * How often have the things you studied in science classes been relevant to another school subject?	7.4%	24.8%	40.3%	21.5%	6.0%
28. * How often have the things you studied in science classes related to things you have learned outside of school?	8.7%	32.0%	43.3%	12.7%	3.3%

Table 15 Continued

124

29. * Science classes are useful?	35.1%	41.7%	20.5%	2.0%	0.7%
30. * Much of science classes are useful in everyday life?	14.6%	37.1%	36.4%	9.9%	2.0%

---

*Note. \* Indicates question was reverse scored*

The quantitative results analyzed to answer research question 1 indicated that students expressed generally positive perceptions of all of the seven constructs assessed. The construct with the highest average perception rating was the construct dealing with lack of anxiety in HUNCH class. The construct with the lowest average rated perceptions was the construct dealing with interest in science. Approximately 78% of the students surveyed indicated that science was *always* or *often* fun. Over half (56.3%) indicated that HUNCH class was sometimes too easy for them. The majority (81.3%) of participants also indicated that they *always* or *often* feel successful in HUNCH class. About one-third (32.3%) of students indicated that they did not feel that they had much choice in topics or projects, while over 68% indicated that they *always* or *often* can work at their own pace. Interestingly less than 50% of the students expressed that they have hobbies that involve science, and only 17.2% indicated that they read magazines *always* or *often* about science topics. About a third of the students (32.2%) rated their impressions of the things they studied in HUNCH classes as *always* or *often* relevant to other school subjects, while an additional 40.3% rated HUNCH science topics as *sometimes* relevant. Over three fourths (76.8%) of students indicated that the HUNCH class was *always* or *often* useful.

### Focus Group Interview Results

The size of the focus groups varied from six to 26 students. Almost ninety percent of focus group participants were males. The focus groups were held in classrooms or offices, within the school, during school hours. During the focus groups, teachers did not participate. Students seemed to enjoy the activity played by picking questions from a bag during the focus groups. However, a good portion of the time was spent on discussions that were spinoffs of the written questions. The specific focus group questions that best answered research question 1 with regard to how students perceive STEM HUNCH courses are found in Appendix E.

### Emergent Themes

This section will focus on the emergent themes from the focus groups that answered research question 1, “How do students who participate in HUNCH programs perceive STEM HUNCH courses and other STEM courses?” The section is divided into five emergent themes, which describe their STEM HUNCH courses as follows: courses are enjoyable, courses are useful, courses are relevant, courses build self-concept of abilities, and courses are student-centered. Within each of these themes are several contributing factors. These contributing factors are substantiated by student quotes, throughout this section. Participants were representative of the typical HUNCH student, from grades 9-12, who were in a STEM HUNCH class for at least one semester.

Enjoyment of STEM HUNCH Classes: The most consistent theme across schools and focus groups were that students enjoyed their STEM HUNCH courses. Enjoyment of

STEM HUNCH classes discussed in this section is not represented by the typical meaning of “fun”, because the things that HUNCH students found to be fun were not typical. Students said such things as electrical wiring and using computer aided design (CAD) programs were fun. Several contributing factors that students expressed as fun in STEM HUNCH classes were the hands-on nature of the classes, the promotion of creative thinking, the opportunity to problem solve on their own, the challenge of the work, the opportunity to learn by doing, and the student-centered nature of the classroom. This section provides quotes by students and their stories to substantiate student enjoyment of STEM HUNCH classes.

Students took great enjoyment in being able to run complicated machinery that very few high school students had at their disposal. In one school, most of their shop machines came from NASA surplus. It was a stretch for both the teacher and students to operate these machines. However, when they accomplished this task students were completely overjoyed. One student stated that after weeks of trying to get the Strip-It machine working (the machine is used to punch precise holes in metal), he was so overjoyed that he hugged his friend standing next to him. The student explained,

We got the Strip-It machine from NASA many years ago, this summer was the first time I had ever used it. I was able to play with the machine and learn on my own how to use the Strip-It, and now I am the only one that knows how to use it. When our teacher comes up to me and says, you need to sit me down one day and teach me how to use it, that's pretty cool.

This is just one story, but there were other similar stories in other schools, in which students were so excited about accomplishing a challenging task that they were overjoyed. As another student said, “Learning how to do it yourself is fun.”

STEM HUNCH courses are perceived by students as classes where they have the opportunities to learn on their own and to use their own skills to solve problems in creative ways. Successfully, accomplishing a challenging problem without the direct instruction of a teacher is seen as fun to HUNCH students. In the focus groups, students told of the many opportunities that HUNCH activities provided them to have such fun. The students at one school had to be enjoying their HUNCH electronics project, because they volunteered after school as a club, just for the fun of working on a wiring project. One of the students explained it this way, “I like science because it’s fun to make science do stuff. I just really enjoy building stuff and all this wiring is fun actually.” Another student at a different school was working on a HUNCH drafting project of a multisensory atmospheric mapping sensor and he said, “The project itself is more challenging than the other stuff we do in class. That’s why I like it.”

The challenging hands-on nature of the HUNCH projects made STEM HUNCH classes more fun for students who particularly did not like seat work. Most HUNCH students reported that they did not like sitting behind a desk, listening to a teacher, reading a book, or doing a worksheet in class. The students reported that during these types of activities it was hard for them to pay attention. The researcher asked one focus group how many students had fallen asleep in their home schools. Every single hand was raised. Then the researcher asked how many of them had fallen asleep in their STEM HUNCH classes, and only one hand went up out of the twenty students in this focus group. It was the hands-on nature of the work that students indicated as providing the

difference between STEM and regular classes. When asked how STEM HUNCH class compared to their regular high school classes one student explained,

I don't really think it compares to it in any way. You actually get a hands-on experience with the math, and you actually get to use it hands-on in a practical way, instead of just studying it.

This hands-on theme was expressed throughout the focus groups at all the schools as an important reason why students enjoyed their STEM HUNCH courses.

Usefulness of STEM HUNCH Courses. The usefulness of STEM HUNCH courses was another prominent theme that emerged from many focus groups. The theme involved the usefulness of STEM HUNCH courses because HUNCH projects promoted a better understanding of both math and science along with problem-solving, creative thinking, and team work. Students expressed that when they were allowed to actually apply their math and science skills to HUNCH projects, they were able to achieve a better understanding of these skills.

Students in an engineering class indicated that an important part of their STEM HUNCH class was that it taught them the usefulness of their math and science education. Their HUNCH projects answered the question, "When are we ever going to use the algebra and physics that we study?" When a student was asked, "Do you have a different view of the importance of science and math classes after being in HUNCH?" he said, "Yeah, we did a lot of equation stuff. We did velocity and momentum and all that."

Students discussed that applying math and science knowledge was the way that they learned best. One student said, "In regular school you learn it and here you apply it and think about it." Another student continued, "Because in regular classes you are



reading out of a book, you're repeating stuff, you're memorizing, and here you are actually doing it." This theme of being able to apply book learning was consistently brought up by students in each school.

The usefulness of learning skills that would be required for future jobs and schooling was mentioned by several focus groups. Students wanted to learn all that they could when they had a future need for the knowledge. A student stated, "I want to learn all I can in machine shop, because I will use these skills in my job." One student in machine shop said, "If you go to college without taking these courses you have to begin at the beginning, and we have a head start. We have a foundation that we are building on." This foundation of skills obtained by the students in STEM HUNCH courses was mentioned by many of the focus groups' participants.

Relevance of STEM HUNCH Classes. The relevance of STEM HUNCH classes was expressed by students who answered the questions, "How useful are the things you learn in STEM HUNCH classes to everyday life?" and "After being in the HUNCH program, how have your feelings toward the relevance of science classes changed?" For some students the answer was that the relevance of science classes did not change, while for others there was a dramatic change. One sophomore explained,

Before I was in the HUNCH program, I didn't think science was going to play that much of a role in my life. But after I've been in the HUNCH program for awhile, I want to know more about science, because I know that if I do want to go into an engineering field, science would play a big role in that career path.

Students often compared the relevance of working on a project for NASA, with the relevance of other projects. The general opinion expressed by students was that they

preferred building important, useful projects for NASA, as opposed to projects whose only relevance was receiving a grade. One student said, “HUNCH gives you a project that means a lot more than a grade.” Another student agreed by saying, “Yeah you have more than just a letter grade to show for your work.” When a student was asked, “Describe three aspects of HUNCH that is of particular value or interest” His first response was, “I would say just the whole thing where you get to build stuff for NASA. That is just really awesome right there.” Building hardware for NASA was seen by the majority of students to be relevant work that helped the country. A student stated, “It’s actually amazing to think that just high school kids can build something that’s for a space station going up into high-tech space.”

Self-Concept of Abilities in STEM HUNCH Classes. Self-concept of abilities in STEM HUNCH classes covered a whole range of student comments, from building student confidence to increasing students’ perceptions of their self-worth. For the most part, students in STEM HUNCH courses were confident about their abilities in STEM skills. Students often expressed confidence about their math and science skills. They liked STEM HUNCH courses because they were able to apply their math and science skills. One student said, “I think everyone here is a math and science person and not really an English person.”

Students felt their self-confidence increased because of learning opportunities that fostered using their own efforts. One student explained,

It’s proof that you can actually do something that makes a difference instead of just parroting something like a teacher tells you or something a teacher showed you. A lot of this, we haven’t gotten much direct help

from the teachers.

Another student in the same focus group stated, “It is quite rewarding because we get to design the thing ourselves and we don’t have the teacher breathing down our necks.” A third student added, “When you have one problem that no one else can get and you’re just like this, and it’s that easy, then everybody else is like, oh.” Opportunities that allow students to think and solve problems by their own efforts entered the discussion of focus groups in all of the schools working on HUNCH hardware.

A student explained exactly how HUNCH activities built his confidence level when he answered the question, “How has HUNCH influenced your self-esteem?” He stated, “HUNCH has influenced me. It has really helped me be more confident in what I do, be sure with what I’m doing. You know I really feel that what I’m doing is right.” When asked by the facilitator why he said it helped his confidence, he explained, “You have to make all these decisions on your own, and it helps you think outside of the box and stuff like that.”

In response to the same question of how HUNCH has influenced their self-esteem, students discussed how increased confidence levels increased their self-esteem. One student explained, “It has made my self-esteem go higher, because I know more about what I’m talking about in HUNCH, than say social studies.” Another student added, “And also you feel more accomplished, instead of just completing an assignment or something we are building stuff for NASA.” And still another student summarized the discussion by saying, “The more confidence you have, the more self-esteem you have.”

Student-Centered Learning in STEM HUNCH Classes. One aspect of student-centered learning is that teachers act more as facilitators than as teachers. This involves students working together, without constant direct instruction from the teacher. Student-centered classrooms usually have students of various abilities, who are permitted to work together on projects. The teacher's role is more like that of a captain responsible for directing activities, rather than a showing how to complete each activity. And this is exactly how the students at one school felt about their drafting teacher, as evidenced by the fact that they referred to him as "Captain." These drafting students felt that the classroom environment was most important to their learning. They all agreed that their teacher was a facilitator, who did not lecture, except for the first month of class. After that, the students learned on their own by asking the teacher or other classmates for help. One student said, "We want a facilitator more than a lecturer."

Some students explained that they learned by doing rather than by direct instruction. One student said, "Because in regular school you are reading out of a book, your repeating stuff, you're memorizing, and here you are actually doing it." Another student explained, "Yeah, like regular school, I don't like going there. It's boring. Because all I do is memorize and regurgitate. But not here." This idea was held by many other focus groups that expressed that trying to learn on their own, or from other classmates, was the best way for them to learn.

The students in an engineering class also mentioned the learning environment of their classroom. One student explained a benefit of being able to find their own way to accomplish a task. While talking about his engineering class he said,

As long as we get it done, it doesn't matter how we did it. In other classes, if we don't do it exactly the right way we will get in trouble, and we will get a zero on it. Here, we get to find our own way to do it.

Another student added,

Yeah, I agree with that. Another thing I like about this class versus other classes is that I like the style of teaching better. Because the teacher will give us an idea and then we will discuss it and break off into groups to tackle it. Each group will tackle a part of the design, and even if we design it to what we think would work and then come back as a whole, if it doesn't work, it doesn't mean we get a bad grade. We just talk about it, discuss it, and redesign.

Comments from two other students supported the notion that the HUNCH program offers a student-centered learning experience. The first one said, "The class is more open. It's not closed off." Then the next student added, "The teacher understands, that even if it's a bad design, it doesn't mean we failed. It's part of the learning process." This last comment brought up another characteristic of a student-centered classroom, which is that mistakes are looked upon as learning opportunities. One student said, "Most classes, you do bad on a homework assignment, instead of being a learning opportunity, you get a bad grade."

Finally, a student in machine shop pointed out an aspect of student-centered classrooms that are not often incorporated into regular academic classrooms. In describing his machine shop class he said, "You learn to become more independent than having someone tell you exactly what to do and how to do it. You do it yourself and it makes you learn more out of it."

In summation, the themes identified from analysis of the focus group interviews fell into several categories. Students in HUNCH programs perceived STEM HUNCH

courses as enjoyable, useful, and relevant. The students also have a positive self-concept of their abilities in STEM coursework. STEM HUNCH courses were fun because they were hands-on and challenging. STEM HUNCH courses were useful because they were able to apply their learning to building valuable products for NASA. Students' success in STEM HUNCH courses depended more on their own efforts, knowledge, and creativity, because the teachers acted more as a facilitator in STEM HUNCH courses.

### Individual Student Interview Results

Student interviews were of the open ended conversational type. However, Appendix E does list some guiding questions that were asked of the interviewees. These questions pertained to how students perceived STEM HUNCH courses. Interviews were conducted with two high school students from different schools. One student was a sophomore from a machine shop class and the other was a senior from a drafting class. The drafting class teacher was also briefly interviewed. Students were recommended by their teachers to be interviewed and the criteria were determined by the teacher, the willingness of the student to be interviewed, and the student's availability. A third college-level student who had previously been enrolled in HUNCH courses was also interviewed. He was presently attending a local college, while working part time for HUNCH at MSFC. Using the interviews from all these participants allowed for an in-depth description of their activities and perceptions. This section paints a picture of the students interviewed and reports on the emergent themes from the interviews that answered research question 1, "How do students who participate in HUNCH programs perceive STEM HUNCH courses and other STEM courses?" In this section two

prominent themes emerged. The emergent themes were students' self-concept of STEM abilities and the promotion of interest in STEM careers by the exposure to STEM courses and professionals.

### Emergent Themes

Self-Concept of Abilities in Math and Science. The machine shop student had been in HUNCH class for two years. She explained why she transferred from her designated school, which did not participate in HUNCH, to a school that was involved in the NASA HUNCH program.

My Mom works at Boeing, and we were just looking at the different schools, and I saw the NASA HUNCH program and I was like I want to take that. And so we went and talked to the machine shop teacher over that summer, and found out what they did, and looked around the shop and then I found out I could transfer for this class.

She was willing to transfer to a different school to be in HUNCH. She was confident that she could learn the necessary skills to succeed in building projects for NASA. When the researcher interviewed her she was a sophomore in her second year in HUNCH. Her perception of her abilities in math and science developed over many years of success and interest in these areas. When asked about her involvement in machine shop she answered,

I'm more math oriented than most people. My brain works in math and science, so this class is easier for me than for most people. And it's not so hard to learn how to work machines. You just have to put in the work.

In response to the question, "How has the HUNCH program influenced your enrollment in math courses?" The interviewee answered,

I guess it's like, it's made me a little more motivated because I know that if I take the more challenging math and science courses then I will be able to progress and build better hardware for HUNCH stuff. I take the harder math and sciences, because I've always loved them.

When the interviewee was asked "How does your desire to do well in HUNCH compare to her other classes?" she answered,

I go into HUNCH class and I'm confident enough to know I'm going to build something, but little things can go wrong. Like, if your metal bends a little and goes across and cuts and you have to start all over because you can't have one wrong cut in a piece of metal. I'm really confident in HUNCH class that I'm going to build everything right. But in math, science, and HUNCH, it's all the same, because I'm good at those. But History and English I have more trouble in. And I'm not as confident in those and I'm not as productive and do not do as well in those classes.

The same type of self-confidence of abilities was seen in a special needs interviewee from a drafting class. He knew he was good in drafting and computers. His self-concept of abilities came from his successes in STEM courses that involved computers. His teacher said that he had a real gift for drafting and therefore put him on the HUNCH project. His teacher said the student was doing an exceptional job for HUNCH.

The teacher was one of the first teachers involved in HUNCH. He started with drafting classes that worked on building training hardware for astronauts such as standoff interface panels. His students were presently working with NASA engineers at MSFC in designing a scale model of the middle stage of the Ares rocket. When the teacher was asked about how he involved the students in HUNCH projects he said,

Basically, I just get things from Bob Zeek, from Marshall Space Flight Center. He gives us projects he would like us to work on and I farm it out to the kids. Once the kids take over all I do is answer



questions and give them pointers.

The senior drafting student was recommended by his teacher to be interviewed, because of his exceptional work for the HUNCH program. He had been in drafting for three years. When asked about his abilities in drafting class, he said, "I'm really good with stuff on the computers." Then the interviewer asked "Why do you think that you are really good on computers?" The student answered, "I got a good teacher. Yeah, he is a really good teacher." To further clarify the interviewees answer, the researcher asked, "Were you interested in this stuff before you had a good teacher?" The interviewee answered, "No, not really. I happened to be put in drafting based on my counselor's recommendation." The student indicated that he did not even know he was good in drafting until he was in the class.

A young man at Marshall Space Flight Center (MSFC) was developing a Flash program that would be used to train astronauts on the ISS. This young man was a freshman at a local university and was studying computer engineering. As a junior and senior in high school he attended a HUNCH vocational technical school. At the HUNCH school, he enrolled in computer electronics. The computer electronics class was doing projects for HUNCH. The college student explained,

So I signed up for computer electronics, and I found out about HUNCH. They were about to start doing Flash and I hadn't done any Flash, so they gave me a book about Flash. Did you see that glass rack at MSFC training Lab? Well I didn't do that exact one, but I do things like that. I did this one in about a day. I'm not done because I don't have any procedures.

The Flash training program for astronauts is a glass screen in which a computer program simulates a piece of equipment or experiment. The astronaut can then practice on

operating the equipment by a key board or by touching the glass screen. Astronauts are trained on equipment and experiments in this way, without actually having to have the equipment or experiment. This student had become so good at Flash that NASA HUNCH hired him part time to continue making Flash programs and other tasks for them. The college student explained that HUNCH allowed him to do things that he was good at.

Interests in STEM Coursework. All three students interviewed were interested in pursuing additional STEM coursework. Two of them would be doing this in college and the sophomore who was interviewed, planned to take advanced science and math courses in high school. All three became interested in STEM courses either by exposure to professionals who worked in STEM fields or by enrolling in STEM courses in high school.

The sophomore interviewed said that she grew up with engineers and astronauts. She explained, “I’ve always wanted to be an engineer, ever since I was little. I’ve always been good at math and sciences and seen what my Mom does.” Then the interviewer asked, “What does your Mom do?” She answered,

She builds software for the ISS, or makes software. I’ve been around astronauts and a whole bunch of people like that my whole life. My first volleyball coach was an astronaut; he recently got to go up to the space station. So I’ve been around it my whole life. My next-door neighbor was an astronaut, but then she moved to Virginia when I was little. Everything in my life has been like, around engineering.

The young lady perceived taking difficult math and science courses as a necessity to better her work on NASA HUNCH projects. She stated, “I know that if I take the more

challenging math and science courses then I will be able to progress and build better hardware for HUNCH and stuff.”

The male senior student interviewed was chosen by his teacher to work on the HUNCH project because of his particular gift in drafting. He did not realize his potential in drafting until he had entered the course. When asked if the HUNCH program has changed his educational goals he answered, “Yes, I want to go into drafting now.” He was interested in space since he was little, but it was his HUNCH drafting class that combined his interest in space with his natural abilities in drafting. When he was asked by the interviewer how he became interested in space he answered, “There is just something about it.” He could not explain it any further. He said his dream was to work for NASA someday.

The college HUNCH student who was interviewed always liked computers. He never realized how his interest in computers could be applied to NASA until he enrolled in a HUNCH computer electronics course in high school. Bob Zeek at MSFC had given the computer science teacher the task of programming a glass screen to help train the astronauts going to the ISS. The teacher gave this task to the interviewee and on his own he learned how to program with Flash. Bob Zeek did visit his class, at least once a week, and he was impressed with the student’s work. That is how the student became a paid intern for HUNCH. The student explained, “I wanted to be a programmer, or at least work with computers. But since I have been exposed to HUNCH, I want to go into computer engineering.”

The results from the interviews can be summarized by two main themes. First, the students had good self-concept, of their abilities in STEM areas, due to multiple factors in their personal histories. Secondly, the interviewees' interests in STEM areas were promoted by their involvement with STEM professionals inside and outside of STEM HUNCH courses.

Research Question 2: How do Students Who Participate  
in HUNCH Programs Perceive STEM Related Careers?

Introduction

Research question 2 was answered from responses to questions 31-35 of the SIMSQ, results from student focus groups and individual student interviews. The results of all three sources of data, including surveys focus groups, and interviews allows for an in-depth view of student perceptions and emergent themes on how HUNCH students perceived STEM related careers.

SIMSQ questions 31-35 dealt with student perceptions of becoming a scientist. The focus group and individual interview results were able to provide further insight into student perceptions of STEM careers. In this section, the results of the SIMSQ will be presented followed by the results from the focus groups and interviews. This section ends with a survey of STEM HUNCH teachers on their knowledge of their past HUNCH students' educational pursuits.

### SIMSQ Results

Students were asked to rate their perceptions of each question based on the following Likert scale descriptors: Strongly Agree = 1, Agree =2, Neutral = 3, Disagree = 4, Strongly Disagree = 5. The Likert scale was based on a scale of 1-5, with 5 being the best possible perception of interest in a science career. A score of 1 indicates a lack of interest in a science career. Questions 31, 33, and 34 were reverse scored so that questions were consistent in assessing positive and negative perceptions in science careers. This consistency is important to allow SMISQ scores to be aggregated and interpreted, as the higher the total score the more positive the perceptions of science careers.

Interest in Science Careers. The questions in the SIMSQ survey that specifically dealt with HUNCH student interest in science careers were questions 31-35. Table 16 specifies the percentage of student responses for each of the Likert scale choices for these questions.

According to the results in Table 16, 71.5% of HUNCH students either *strongly agreed* or *agreed* that a job as a scientist would be interesting, while over 70% *strongly agreed* or *agreed* that they would like to work with people who make discoveries. However, less than half of the HUNCH students (47 %) indicated that they *strongly agreed* or *agreed* with the statement that they want to be a scientist. These results are supported by the fact that over 70% of HUNCH students *strongly disagreed* or *disagreed* that a career in science would not be interesting.

Table 16. Percent of Frequency Results for Interest in Science Careers by HUNCH Students

<i>Student Interest in Science Careers</i>	<i>Strongly Agree (1)</i>	<i>Agree (2)</i>	<i>Neutral (3)</i>	<i>Disagree (4)</i>	<i>Strongly Disagree (5)</i>
31. * I would like to be a scientist	18.5%	28.5%	29.1%	13.9%	9.9%
32. I would <b>not</b> like a job in a science laboratory	5.3%	19.2%	27.2%	29.8%	18.5%
33. * I would like to work with people who make discoveries in science	19.2%	47.7%	21.9%	7.3%	4.0%
34. * A job as a scientist would be interesting	33.8%	37.7%	19.2%	6.0%	3.3%
35. A career in science would <b>not</b> be interesting	8.6%	9.9%	10.6%	33.1%	37.7%

---

*Note \* Indicates question was reverse scored*

### Focus Group Interview Results

The focus groups involved students answering predetermined questions. The specific questions that best answered research question 2 on how students who participate in HUNCH programs perceived STEM related careers are found in Appendix E. These questions frequently acted as starting points to in-depth discussions.

Only the emergent themes dealing with research question 2 are reported in this section. Two themes emerged from the focus groups. The first was that friends and families played a large part in career choices and the second was that exposure to STEM

courses and careers were influential in motivating students to pursue a career in STEM areas.

Friends and Family. One theme that emerged from the focus groups that influenced students to become engineers was the influence of their friends and family. If students' relatives or friends were STEM professionals then the student was more familiar with STEM careers. This was indicated by several students whose exposure to engineering started at a young age. These students were very familiar with the work of engineers, because their parents, relatives, or friends were engineers. One engineering student said that his father was an engineer for NASA and that he grew up around engineers. Most of the other students in this engineering class said that their parents worked in STEM areas.

One student explained how his grandfather was a motivating factor for him to become an engineer. His story follows,

Well, I remember when I was small I used to go to my granddad's house, and I would build a house out of nothing basically, and he would always tell my Dad that's an engineer right there. I always picked up on that, and around the 4<sup>th</sup> grade I looked it up, because I wanted to build houses and everything and malls and everything, and that's exactly what I wanted to be, because this is what I love doing. I would always take apart things and put them back together again to see how they worked. I have just always loved engineering.

The other students in his focus groups agreed that family member's perceptions of their abilities contributed to their career plans. This theme of parents, friends, and teachers' perceptions of students' abilities and how they influenced students' career choices was talked about frequently in the focus groups. However, the most frequent

theme was how being involved in STEM HUNCH courses had influenced students' decisions to pursue STEM careers.

Exposure to STEM HUNCH Classes. Some students were not exposed to engineering until they entered a STEM HUNCH class. They said that being in the STEM HUNCH class started them to think about becoming an engineer and to continue their STEM education after high school. One student said,

It's kinda led me to the way of being an engineer, because before I was just going to be someone who goes into automotive, and now I'm looking more toward the engineering side I guess... Oh, I've realized that in an automotive shop, it would be repetitive, and I would be doing the same thing over and over and over again. And if I were an engineer, I would be working with different materials and different projects, instead of doing the same thing.

Another student worked as a summer intern for HUNCH building "Merlin," the refrigerator/oven for training astronauts. He said that his STEM HUNCH class experience and his summer internship convinced him to become an engineer. "That's what did it" he said, when asked why he wanted to be an engineer.

In a machine shop class, an unusual number of students wanted to be engineers and they said that their experience in the STEM HUNCH class is what made them want to be engineers. One student put it this way,

Before I was in the HUNCH program, I didn't think science was going to play that much of a role in my life. But after I've been in the HUNCH program for awhile, I wanted to know more about science, because I know that if I do want to go into the engineering field, then that would play a big role in that career path.



One young lady already had a job at the Army Arsenal in Huntsville with electrical engineers and she said her work there convinced her that she wanted to be an electrical engineer. Before obtaining that job she was thinking of becoming a lawyer.

Students often discussed how enrolling in STEM courses were a testing ground to see if they wanted to pursue a STEM career. One student explained,

I mean some of the stuff is interesting (referring to courses in his comprehensive school), but when you come over here (vocational school), I mean especially if you want a career out of something you are doing over here, it makes it just that much more interesting. You can get more into your career. I mean here, it's basically like the testing center. If you think you want one career you come over here and you get a taste of what it's really like, and then you can decide if you want to do it. Here, it serves as an eye opener basically.

The other students agreed that having the opportunity to experience different STEM classes was a contributing factor to knowing if they wanted to pursue a career in that area.

### Individual Student Interview Results

The individual interviews were of the open ended conversational type. However, specific questions about how HUNCH students perceived STEM careers are found in Appendix E. These questions were used as guides during the interviews. Interviews were conducted with two high school students from different schools and a previous HUNCH student. One student was a female sophomore from a machine shop, and the other was a male senior from a drafting class. Students were recommended by their teachers to be interviewed based on their availability. A third student who had previously been enrolled in HUNCH courses, and was now attending a local college while working part-time for

HUNCH at Marshall Space Flight Center, was interviewed. There were two themes that emerged from the interviews with regard to career interest in STEM areas. These two themes were the influence of family and friends and the exposure to STEM courses.

Family and Friends. The sophomore student in machine shop said that her neighbor and her volleyball coach had been astronauts and that knowing them had an impact on her wanting to pursue engineering. Also her mother worked as a computer software engineer for Boeing. She joined the HUNCH machine shop class to get more experience with engineering, since she planned to go to college for engineering. She explained her career plans as, "I want to go to an Ivy League school to play volleyball and to continue engineering, but I'm not sure in what field yet, probably building software or hardware for Boeing or NASA, so it will still be aeronautics."

Exposure to STEM HUNCH Classes. The senior drafting student planned to go to college and study drafting and or game design. He eventually wanted to work for NASA. He said, "Working for NASA is a really big dream job for me." This dream started in his drafting class when his teacher put him on a HUNCH drafting project. He had always been interested in space so once he found out how his drafting talents were applicable to working for NASA his dream to work for NASA formed.

The college student who was interviewed already knew he wanted to go into a career in computers before he was enrolled in a HUNCH computer electronics course. However, after working on the HUNCH project involving Flash programming, he

decided to pursue a career in computer engineering. His work on Flash programming lead him to an internship and part time job for HUNCH at MSFC.

Two prominent themes emerged from the focus groups and individual student interview results dealing with research question 2, which asked, “How do students who participated in HUNCH programs perceive STEM related careers?” The two themes that emerged were that they have positive perceptions of STEM careers, which were influenced by friends and families. Also, student involvement in STEM HUNCH classes influenced them to pursue STEM careers. Students explained that knowing people in STEM careers exposed them to engineering and other STEM areas. However, being exposed to STEM HUNCH classes was also influential. These classes provided them with the opportunities to explore their abilities, while working for NASA.

### Teachers’ Survey

To further gain insight on research question 2 a survey was mailed to teachers asking about past HUNCH student enrollment in post-secondary STEM education. This section reported the results of two questions that were sent to teachers after the researcher’s visit to their classrooms. A self addressed envelope to be mailed back to the researcher with the answer to the questions was included in the survey request. The two questions were as follows:

- (1) Over the years, how many students have you had involved in the HUNCH program?
- (2) To the best of your knowledge, how many of these students, after graduation have continued their education in science, technology, engineering, or mathematics (STEM) career areas?

These questions were asked to each of the ten HUNCH classroom teachers that were visited, but teachers indicated that they could not answer them without some checking on their past students. All but one teacher sent back a response, which resulted in a 90% response rate. Table 17 summarizes the responses of the teachers to both questions and indicates the percentage of students in post-secondary STEM education. The percent of past HUNCH students enrolled in post-secondary STEM programs of study across the nine schools averaged 69%.

Table 17. Frequency of Students Participating in HUNCH Who Continued in STEM Courses Beyond High School

<i>Teacher #</i>	<i>Question 1: Over the years, how many students have you had involved in HUNCH Program?</i>	<i>Question 2: How many students continued their education in STEM areas?</i>	<i>Percentage of Students in Post-Secondary STEM Education</i>
1	20	20	100 %
2	30	28	95%
3	10	9	90%
4	160	140	88%
5	40	31	78%
6	30	18	60%
7	30	15	50%
8	120	50	42%
9	12	3	25%
<b>Total</b>	<b>452</b>	<b>314</b>	<b>Average = 69%</b>

Research Question 3: What Learning Experiences do HUNCH Students Describe as Motivating Them Toward Pursuing Courses and Careers in STEM Areas?

Introduction

In this section, only the results from focus groups and interviews are presented.

The SIMSQ results are not presented because their results were limited to the

motivational constructs of the questionnaire that have already been presented. The researcher felt that focus groups and interviews would provide student generated ideas on learning experiences that motivated students to pursue courses and careers in STEM areas.

### Focus Group Interview Results

The specific focus group questions that best answered research question 3 on what learning experiences students describe as motivating them toward pursuing courses and careers in STEM areas are written in Appendix E. In this section, only the emergent themes dealing with research question 3 were reported. There were five motivating themes that emerged as follows: the hands-on nature of the learning experience, the challenging nature of the learning experience, the environment of the learning experience, the lack of anxiety of the learning experience, and the relevance of the learning experience. These emergent themes not only overlap with the quantitative results, but add depth of understanding to previous results. For example, while enjoyment of learning is a previous theme, the hands-on, challenging nature of the work explains why students enjoyed STEM HUNCH class work. The results below were organized by these emergent themes.

### Emergent Themes

The Hands-on Nature of the Learning Experience. The most prevalent theme in all the focus groups was about the benefits to learning for students in a hands-on learning environment. In answering the question how does HUNCH class compare to other math

and science classes all the students agreed that the hands-on nature of the class was the main difference. One student explained,

It gives me a more hands-on feel for sure. In my science and math classes, they will be trying to teach me something on the board and I learn more if I'm doing it, if I'm using my hands to learn about it. Then, I'll learn it better.

Another student agreed that the biggest motivating factor for him was the hands-on work. He said,

I think just since it's hands-on, and you don't have to sit and listen to a teacher preach and give you a worksheet. You actually get to do some hands-on experiment, experience and stuff. It's different and a little more exciting.

A third student answered the question of why she enrolled in the HUNCH program by stating, "Because you're not just sitting down doing book work, you're actually building something." Students continually made comments about how they learned best by doing hands-on work. Another student answered the question how does HUNCH class compare to your other math and science classes by saying, "Well, this is more hands-on. You still learn math and science, but it's more hands-on. I'm a more hands-on learning kind of person so it's more beneficial." Comments about hands-on work were the most prevalent response.

The Challenging Nature of the Learning Experience. The challenging nature of the learning experience in STEM HUNCH classes emerged as a constant theme in all the focus groups, second only to the hands-on nature of the work. Students made comments such as, "It's a lot more stimulating, because it makes you think a lot, and you have to think about what you are doing. You have to pay attention." Most students agreed that

they were motivated by thinking through a challenging problem and not by being given step by step instructions on how to do something. One student in response to the question what specific activities of the HUNCH program he liked best said,

I would say just the whole thing where you get to build stuff for NASA that is just really awesome right there. They say, hey you guys, help us build stuff that we are going to possibly send into space if you don't totally screw it up.

The very nature of building hardware for NASA involved challenging learning experiences. One machine shop student explained,

You gotta think about what's gonna work and what's not. I mean you got the wrong density and it will just crush in space. You have to make sure it will withstand all the Gs they put on it and everything like that. Everything has to be as light as they can make it. They can't put extra materials on it to make it too heavy. I mean its detailed work. You have to have a biography on every little piece and bolt and what it is made out of.

Another student put it this way,

I mean it's cool to do the NASA stuff and help them, but you walk away with skills that you will never forget. You learn to take your time. It's always going to come out better, and teamwork is always good.

One drafting class focus group discussed how they enjoyed the challenge of HUNCH work. One student said, "This class is more of a challenge. Even if it is more difficult, we enjoy it more." The students said that they enjoyed the class, because the projects they had to do were challenging and they were interested in the work. Students often mentioned how they liked problem-solving and how the HUNCH projects always had a lot of problems to solve. One student said, "I have always really liked problem-solving and this class definitely has a lot of it."

The Environment of the Learning Experience. Students in focus groups often discussed how the environment of the STEM HUNCH class was different from other classes. There were several factors of the environment that students continually mentioned. These factors were being able to find their own solutions to problems, having competent teachers, and having opportunities to learn within a community of learners of different abilities. The following paragraphs discuss how these factors created a unique learning experience.

One perception identified from these interviews was that students appreciated the fact that they could find their own solutions to problems that developed frequently when fabricating hardware. Students discussed the fact that they were given challenging problems and told to find their own solutions. One student said, “It is quite rewarding because we get to design the thing ourselves and we don’t have the teacher breathing down our necks.”

Students also expressed the importance of being able to solve a problem with as little help as possible from their teachers. One student said, “In other classes, if we don’t do it exactly the right way we will get in trouble, and we will get a zero on it. Here, we get to find our own way to do it.” Another student commented, “A lot of this, we haven’t gotten much direct help from the teachers.” Then this student added that it was more motivating to get help from each other than from a teacher. One student summed it up by stating, “We rely on other students, and because of that our classes are more student oriented.”



Another frequently mentioned factor was the importance of having competent teachers. Students often felt their teacher made the difference between a good and a bad learning experience. One student said,

The teacher is a big deal. If you have a crappy teacher you're not going to want to study. If you have a good teacher that teaches you things that make you go, oh my G-d this is interesting, and then you will want to go home and read it or do stuff about it.

This student felt that the teacher was the most important factor in the learning environment. Throughout most of the focus groups, the teacher, and/or the HUNCH engineer, was mentioned as a motivating influence on the HUNCH students. One student told about his learning experience which involved working with the HUNCH engineer by saying,

We worked on Merlin. Merlin is a dorm refrigerator for the space station. It can either keep things cold or they can reverse it and heat things up in it too. It was amazing to watch Mr. Hale figure things out.

A final factor of the classroom environment was the importance of a learning community where everyone was valued. The following is a description from a focus group in an engineering class of what took place. Students discussed why they liked their engineering classes. One student said that the HUNCH engineering class was his favorite class because, "In all my other classes, I have to worry about like, what are we going to do, and in this class, it's more relaxed. You get to work with people." The other students agreed and another student said, "I have a lot of AP classes and they are kind of stressful." The reasons students gave for HUNCH class not being as stressful were as follows: No idea is a bad idea, people want to be in this class, you can be more open in this class, and we are a pretty close-knit group. Students appreciated the friendly

environment of their HUNCH classes. Very similar comments were made about the other classes involved in HUNCH. One student said, “This class, with each of us being at different levels, if the teacher is busy, then I can ask one of the students.” Students frequently talked about learning from each other as a positive characteristic of their STEM HUNCH classes.

The Lack of Anxiety of the Learning Experience. Students discussed how STEM HUNCH classes added anxiety because they were working for NASA. Some students felt that working for NASA was a stressor. A student expressed it by saying, “Trying to impress someone as important as NASA brings stress.” However, the majority of students felt that STEM HUNCH classes were less stressful than their regular classes.

One student expressed it this way,

If you can't focus on a day then you can basically just take that day off and work twice as hard the next day, because you're behind. Rather than just being like, I'm like eight days behind in my math homework and I just don't care.

Another student said, “It seems like you can be more laid back here than in a regular class.”

Students discussed mistakes being viewed as learning opportunities as an important factor that lessened anxiety in the STEM HUNCH classes. The following were quotes from students on this issue. One student explained the value in making mistakes as, “If you didn't make mistakes, then you wouldn't know how to handle one if a problem occurs.” Another student explained how solving problems generated by making mistakes presented them with learning opportunities. He said, “Just dealing with

problems as they pop up, you have to deal with that in drafting a lot. But in other classrooms, the problems are already there, they don't just pop up." Students often indicated that being able to make mistakes without ending in failing grades was important to them.

Another issue that lessened anxiety in the STEM HUNCH classroom was the lack of deadlines. One student explained how deadlines interfered with motivation to learn. She said,

If you are goofing off then I can understand for a deadline, but if you are making progress then it shouldn't be this has to be done. That puts pressure on you and that makes you nervous, that makes you make mistakes and makes the quality of work go way down.

Another student said, "When the timer is going I am thinking of how much time I have left rather than the work." Students agreed that when a student is working hard having a deadline adds stress that interferes with their learning. One student summed it up by saying, "If I have a timer on me I am just going to get an F and go. I just can't think with a timer." The student participants in this particular focus group felt strongly that due dates negatively influenced their desire to learn. This issue was brought up at several focus groups.

The Relevance of the Learning Experience. Every focus group discussed how important working on a relevant project was to their motivation to learn. One student said, "HUNCH gives you a project that means a lot more than a grade." Another student said, "We don't do busy work, which makes me happy beyond belief." Providing

students with the opportunity to learn from real-world, valued projects made their learning relevant and useful. One student said,

The difference between this HUNCH class and other classes are like, physics is more conceptual, and you're not putting it into real life and seeing how it will affect the outcome. Whereas, in this class it will affect the outcome...So what it does is give you a basis to apply the concepts of what you're learning to real world applications.

This student said this motivates him because, "It's a whole lot easier to understand than when you have a theory or concept thrown at you." All the students agreed that when they were able to apply their learning to real-world situations the learning was made easier to understand.

Other students acknowledged that being able to fabricate things that were useful to others was motivating. The following are comments made by students about this theme. "You're not just working for high school grades you're actually doing something to help NASA." Another student stated, "Its proof that you can actually do something that makes a difference instead of just parodying something a teacher tells you or something a teacher showed you."

### Individual Student Interview Results

The interviews were of the open ended conversational type. However, specific questions about what learning experiences HUNCH students described as motivating them toward courses and careers in STEM areas are found in Appendix E. These questions were used as guides during the interviews.

Interviews were conducted with two high school students from different schools. One student was a female sophomore from a machine shop, and the other was a male

senior from a drafting class. Students were recommended by their teachers to be interviewed. A third student who had previously been enrolled in HUNCH courses and was now attending college was interviewed. He was presently attending a local college, while working part time for HUNCH at MSFC. Using the interviews from all these participants allowed for an in-depth description of their activities and perceptions. This section paints a picture of the students interviewed and reports on the emergent themes from the interviews that answered research question 3 what learning experiences do HUNCH students describe as motivating them toward pursuing courses and careers in STEM areas? In this section, two prominent themes emerged. The most prominent theme was that the students felt they had natural abilities in STEM areas. The other theme was the influence of family, friends, and teachers on their decisions to pursue STEM careers.

Self-Concept of Ability in STEM Areas. The female student interviewed mentioned that she had a natural ability in math and science, and this motivated her to study these areas. She said,

I've always wanted to be an engineer, ever since I was little. I've always been good at math and sciences and seen what my Mom does. I'm more math oriented than most people. My brain works in math and science, so this class is easier for me than for most people.

She also spoke about how her natural abilities brought about confidence and how that motivated her to take courses such as HUNCH. She said,

I go into HUNCH class and I'm confident enough to know I'm going to build something. But History and English I have more trouble in, and I'm not as confident in those and I'm not as productive and so do not do as well in those classes.

The high school student interviewed in drafting class talked about how his interests and abilities came together in the HUNCH project. He had always loved space exploration, computers, and particularly video games. This student did not know much about drafting, but his counselor had recommended that he enroll in the course. In drafting class, he discovered that not only did he enjoy drafting, but that he was also very talented in the subject. The student explained it this way, “Yes, now I want to get into drafting. If I don’t go into game design, drafting would be my secondary thing. Working for NASA is a really big dream job for me.”

The third student interviewed was a graduate of the HUNCH program. He said that he liked writing computer programs, and his work for HUNCH gave him the opportunity to learn new programs and apply his natural abilities in this area. He was so talented that he taught himself how to program in FLASH for a glass rack that was used to train the astronauts. He said, “HUNCH allowed me to do stuff I wanted to learn. I had been interested in FLASH before, and learned that HUNCH wanted to do FLASH, and thought, well I’ll do FLASH now.”

Influence of Others on Decisions to Pursue STEM Careers. The second theme to emerge from the interviews was how important the influence of family, friends, and teachers was to the interviewees. All three interviewees talked about how their career goals were influenced by others. The following paragraphs were quotes from the three interviewees about this theme.

The female student interviewed explained that her mother as well as her neighbors were employed in STEM careers related to the space industry. She commented in reference to her mother's work that,

She builds software for the ISS, or makes software. I've been around astronauts and a whole bunch of people like that my whole life. My first volleyball coach was an astronaut; he recently got to go up to the space station. So I've been around it my whole life. My next-door neighbor was an astronaut, but then she moved to Virginia when I was little. Everything in my life has been like, around engineering.

The drafting student said he did not realize that he was good at drafting until his teacher asked him to work on the HUNCH project because he had an interest in NASA and was talented in drafting. This student explained his involvement in HUNCH by stating, "I think you get to do something that you like to do, and you are very involved with it. I am really good with stuff on the computers." When asked if he was interested in drafting before he had the drafting class he replied, "No, not really. I just happened to put drafting on my schedule."

The college student who was interviewed had a similar experience that involved him with HUNCH. He signed up for an electronics computer course as a junior in the career center for his district. When he was asked how the HUNCH program influenced his career choice of computer engineering, he said,

It got me somewhat into engineering. I wanted to be a programmer, or at least work with computers. It probably would have been more computer science than engineering. During the summer, during my junior year, I came to MSFC to work. And I did a fast and good enough job that they hired me after I graduated.

Actually, the two emergent themes of the interviews are linked together. Certain students who have a natural ability in STEM areas are often encouraged by others and given

opportunities that lead to experiences that influenced them to use their talents in STEM areas.

### Summary of Focus Groups and Interview Results

In summary, the five most prominent emergent themes from the focus groups were the hands-on nature of the learning experience, the challenging nature of the learning experience, the environment of the learning experience, the lack of anxiety of the learning experience, and the relevance of the learning experience. The two most prominent emergent themes from the interviews were the students' perceived abilities in STEM areas and the influence of others on STEM career choices. These themes appeared to account for a large percentage of what motivated students to pursue courses and careers in STEM areas.

#### Research Question 4: Do Students Who Have Two or Fewer Semesters in HUNCH Perceive STEM Courses and Careers Differently Than Students Who Have Participated in Three or More Semesters in HUNCH?

### Introduction

Research question 4 was answered using all thirty-five questions from the SIMSQ. Questions 1-30 answered how students perceived STEM courses. Questions 31-35 answered how students perceived STEM careers. The focus groups were a joint grouping of all the students both new and experienced in HUNCH. This was done to generate diversity of viewpoints among the students, which can lead to better discussions. Also, the focus groups were not broken up into the new and experienced in HUNCH groups in order to lessen the loss of classroom time for all students. Therefore, the results



from focus groups did not yield appropriate results on differences of student perceptions between the new and experienced in HUNCH groups. For that reason, focus groups will not be discussed in this section. Individual student interviews also do not reveal differences between the two groups, because only students who were involved in HUNCH for at least a year or more were interviewed.

The questions from the SIMSQ are broken down into the seven constructs that are listed in Table 4. The following results are a descriptive and comparative analysis of each construct using SPSS. Since the questions within each of these constructs are conceptually related, the Multivariate Analysis of Variance (MANOVA) was used to compare new and experienced in HUNCH student perceptions on each of the seven constructs assessed by the SIMSQ. The SIMSQ data was divided into two groups of HUNCH students that made up the independent variables of students that were new to HUNCH (0 to 2 semesters in HUNCH) and experienced in HUNCH (3 to 4 semesters in HUNCH). One way multivariate analyses of variance (MANOVA) were conducted to compare the perceptions of new to HUNCH and experienced in HUNCH students for each of the seven motivational constructs. This grouping was made after statistical analysis found no significant differences in responses between students never in HUNCH class through their second semester in HUNCH. The results are presented in separate sections with tables for each of the seven constructs.

### SIMSQ Results

The mean scores were derived from averaging the Likert scale numerical values for each of the student responses to the SMISQ questions. Students were asked to rate

their perceptions of each question based on the following Likert scale descriptors:

Always = 1, Often = 2, Sometimes = 3, Seldom = 4, Never = 5. The higher number chosen, the more positive student perceptions of the questions. Questions 2-9, 14-31, 33, and 34 were reverse scored, so that the higher the average the more positive the student perceptions. The results of the SIMSQ indicated that student perceptions in all of the questions except one were more positive overall for the experienced in HUNCH students when compared to the new to HUNCH students. There were 169 HUNCH students that took the SIMSQ.

#### Enjoyment of Science Comparison for

#### New and Experienced in HUNCH Groups. The purpose of this section is to report

the results of the differences in SIMSQ responses of students on how well they enjoyed science classes. Table 18 reports the mean scores for the enjoyment of science questions for both the new and experienced in HUNCH groups. The mean was used to indicate which group had more positive responses to the enjoyment of science classes.

Table 18 presents the descriptive statistics and the univariate ANOVA results from the MANOVA analysis for the first six questions in this study that pertain to the enjoyment of science. The data met the assumptions for the normality of the distribution of the data and equal variances indicating that the MANOVA analysis would be robust for comparing the new and experienced groups across the enjoyment of science questions. Overall results from the one way MANOVA comparing new and experienced in HUNCH groups across all six enjoyment of science questions was not found to be significant, Wilks's  $\Lambda = .249$ ,  $F(6, 145) = .565$ ,  $p = .870$ . Results from the univariate

portion of the MANOVA analysis found group perceptions differed significantly on only question 1, “How often are science classes boring?”  $F(1,167) = 6.748, p = .010 (\eta^2 = .043)$ . This result indicates that experienced HUNCH students felt that HUNCH courses were significantly less boring than the new to HUNCH group who had fewer than 3 semesters of HUNCH coursework. Although this result was significant, the effect size  $\eta^2$  for this comparison was small suggesting that perceptions of science classes as boring explains a small to moderate amount of the difference between new and experienced in HUNCH responses.

Table 18. Descriptive Statistics and MANOVA Results for Comparison of HUNCH Experience by Semester for Enjoyment of Science Questions ( $N = 169$ )

1. How often are science classes boring?	<i>M</i>	<i>SD</i>	<i>F(1,167)</i>	<i>p</i>	$(\eta^2)$
New	3.50	.91	6.75	<b>.010</b>	.043
Experienced	3.86	.65			
2.* How often are science classes fun?					
New	3.660	.71	3.132	.08	.020
Experienced	3.924	.880			
3.* How often are science classes interesting?					
New	4.05	.880	.681	.41	.004
Experienced	4.17	.740			

Table 18 Continued

4.\* How often do you like to go to science class?

New	3.780	1.14	3.225	.075	.021
-----	-------	------	-------	------	------

Experienced	4.10	.950			
-------------	------	------	--	--	--

5.\* How often does science make you curious?

New	3.93	.843	.004	.950	.000
-----	------	------	------	------	------

Experienced	3.91	.87			
-------------	------	-----	--	--	--

6.\* How often do you enjoy science laboratory work?

New	4.379	.818	.120	.730	.001
-----	-------	------	------	------	------

Experienced	4.394	.762			
-------------	-------	------	--	--	--

---

*Note.* \* Indicates question was reverse scored

Self-Concept of Ability Comparison for New and Experienced in HUNCH Groups. The purpose of this section is to report the results of the differences in SIMSQ responses with regard to students' self perceptions of their abilities in HUNCH classes. Table 19 reports the mean scores for the self-concept of ability questions for both the new and experienced in HUNCH groups. The mean scores were derived from averaging the Likert scale numerical values for each student's response to questions 7-9. All of the questions in this SIMSQ dimension were reverse scored. The mean was used to indicate which group had more positive responses to the self-concept of abilities in HUNCH classes.

Table 19 presents the descriptive statistics and the univariate ANOVA results from the MANOVA analysis for questions 7-9 in this study that pertains to self-concept of abilities. The data met the assumptions for the normality of the distribution of the data and equal variances indicating that the MANOVA analysis would be robust for comparing the new and experienced groups across self-concept of abilities questions. Overall, results from the one way MANOVA comparing new and experienced in HUNCH groups across all three self-concept of abilities questions was not found to be significant, Wilks's  $\Lambda = .333$ ,  $F(3, 161) = .552$ ,  $p = .768$ . Results from the univariate portion of the MANOVA analysis found groups perceptions differed significantly on only question 9, "How often has HUNCH class made you feel successful?" The statistically significant results were as follows,  $F(1, 167) = 10.522$ ,  $p = .001$  ( $\eta^2 = .060$ ). This result indicates that experienced HUNCH students felt that they were significantly more successful in HUNCH courses than the new to HUNCH group of students who had fewer than 3 semesters of HUNCH coursework. The difference between the experienced and new to HUNCH groups was not only significant but found a moderate effect for the comparison between new and experienced in HUNCH perceptions of their success with HUNCH coursework.

Table 19. Descriptive Statistics and MANOVA Results for Comparison of HUNCH Experience by Semester for Self-Concept of Abilities Questions ( $N= 169$ )

	<i>M</i>	<i>SD</i>	<i>F(1,167)</i>	<i>p</i>	( $\eta^2$ )
7. * How often have the things you studied in HUNCH class been too easy?					
New	2.990	.846	.001	.969	.000
Experienced	2.985	.813			
8. * How often has HUNCH class made you feel confident?					
New	3.814	.876	3.497	.064	.021
Experienced	4.061	.699			
9.* How often has HUNCH class made you feel successful?					
New	3.941	.915	10.522	<b>.001</b>	.060
Experienced	4.364	.598			

*Note.* \* Indicates question was reverse scored

Lack of Anxiety in HUNCH Classes Comparison  
for New and Experienced in HUNCH Groups. The purpose of this section is to report the results of the differences in SIMSQ responses of students on how they perceived their anxiety levels in HUNCH classes. Table 20 reports the mean scores for the student perceptions of anxiety questions for both the new and experienced in HUNCH groups. The mean scores were derived from averaging the Likert scale numerical values for each student response to questions 10-13. None of these questions were reverse scored. The mean was used to indicate which group had more positive responses to anxiety in HUNCH classes.

Table 20 presents the descriptive statistics and the univariate ANOVA results from the MANOVA analysis for questions 10-13 in this study that pertain to anxiety in HUNCH classes. The data met the assumptions for the normality of the distribution of the data and equal variances indicating that the MANOVA analysis would be robust for comparing the groups across lack of anxiety questions. Overall results from the one way MANOVA comparing new and experienced in HUNCH groups across all four anxiety questions was not found to be significant, Wilks's  $\Lambda = .260$ ,  $F(4, 162) = 1.163$ ,  $p = .321$ . Results from the univariate portion of the MANOVA analysis found group perceptions did not differ significantly on any questions. This result suggests that perceptions of relevance of science classes detected small effects for the comparisons between new and experienced in HUNCH responses related to their perceptions of anxiety with HUNCH coursework.

Table 20. Descriptive Statistics and MANOVA Results for Comparison of HUNCH Experience by Semester for Lack of Anxiety Questions ( $N= 169$ )

	<i>M</i>	<i>SD</i>	<i>F(1,167)</i>	<i>p</i>	( $\eta^2$ )
10. How often has HUNCH class made you feel uncomfortable?					
New	4.311	.897	.043	.835	.000
Experienced	4.303	.992			
11. How often has HUNCH class made you feel unable to understand?					
New	4.078	.848	.935	.335	.006
Experienced	4.212	.755			
12. How often has HUNCH class made you feel stupid?					
New	4.447	.849	1.661	.199	.010
Experienced	4.606	.742			
13. How often has HUNCH class made you feel unhappy?					
New	4.490	.817	1.689	.196	.010
Experienced	4.652	.734			

#### Ability to Make Choices in HUNCH Classes

Comparison for New and Experienced in HUNCH Groups. The purpose of this

section is to report the results of the differences in SIMSQ responses of students on how well they were able to make choices in HUNCH classes. Table 21 reports the mean scores for questions relating to the ability to make choices for both the new and experienced in HUNCH groups. The mean scores were derived from averaging the Likert scale numerical values for each of the student responses to questions 14-18. All of the SIMSQ questions in this dimension were reverse scored. The mean was used to indicate which group had the most ability to make choices in HUNCH classes.



Table 21 presents the descriptive statistics and the univariate ANOVA results from the MANOVA analysis for questions 14-18 in this study that pertain to the ability to make choices. The data met the assumptions for the normality of the distribution of the data and equal variances indicating that the MANOVA analysis would be robust for comparing the new and experienced groups across questions regarding the ability to make choices. Overall, results from the one way MANOVA comparing new and experienced in HUNCH groups across all five questions regarding the ability to make choices was not found to be significant, Wilks's  $\Lambda = .508$ ,  $F(5, 160) = .755$ ,  $p = .672$ . Results from the univariate portion of the MANOVA analysis found group perceptions differed significantly on questions 14 and 17, "How often have you chosen a topic or project yourself for this HUNCH class?" and "How often have you had the chance to work at your own pace in this HUNCH class?" These statistically significant results were as follows,  $F(1, 167) = 7.163$ ,  $p = .008$  ( $\eta^2 = .042$ ) and  $F(1, 167) = 4.579$ ,  $p = .034$  ( $\eta^2 = .027$ ) respectively. These results indicate that students in the experienced in HUNCH group expressed significantly greater positive perceptions of their ability to choose a topic or project and to work at their own pace in HUNCH class than the new to HUNCH group. These results found small to moderate effects for the comparisons between new to HUNCH and experienced to HUNCH students related to their perceptions of ability to make choices and work at their own pace in HUNCH classes.

Table 21. Descriptive Statistics and MANOVA for Comparison of HUNCH Experience by Semester for Questions Regarding the Ability to Make Choices ( $N= 169$ )

	<i>M</i>	<i>SD</i>	<i>F</i> (1,167)	<i>p</i>	( $\eta^2$ )
14. * How often have you chosen topic or project yourself for this HUNCH class?					
New	2.738	1.057	7.163	<b>.008</b>	.042
Experienced	3.167	.887			
15. * How often have you chosen the way you want to learn in this HUNCH class?					
New	2.903	1.142	2.517	.115	.015
Experienced	3.197	1.056			
16. * How often have you selected the order in which you study science topics in this HUNCH class?					
New	2.602	1.149	2.628	.107	.016
Experienced	2.879	1.074			
17.* How often have you had the chance to work at your own pace in this HUNCH class?					
New	3.777	1.120	4.579	<b>.034</b>	.027
Experienced	4.152	.808			
18.* How often have you had the chance to decide when to hand in assignments and take tests in this HUNCH class?					
New	2.196	1.161	2.738	.100	.016
Experienced	2.508	1.226			

*Note.* \* Indicates question was reverse scored

Interest in Science Comparison for  
New and Experienced in HUNCH Groups. The purpose of this section is to report the results of the differences in SIMSQ responses of students with regard to their interest in science. Table 22 reports the mean scores for the interest in science questions for both

the new and experienced in HUNCH groups. The mean scores were derived from averaging the Likert scale numerical values for each of student responses to questions 19-26. All of these SIMSQ questions in this dimension were reverse scored. The mean was used to indicate which group had more positive responses to interests in science.

Table 22 presents the descriptive statistics and the univariate ANOVA results from the MANOVA analysis for questions 19-26 in this study that pertain to interest in science. The data met the assumptions for the normality of the distribution of the data and equal variances indicating that the MANOVA analysis would be robust for comparing the new and experienced in HUNCH groups across interest in science questions. Overall results from the one way MANOVA comparing new and experienced in HUNCH groups across all eight interest in science questions was not found to be significant, Wilks's  $\Lambda = .522$ ,  $F(8, 156) = .857$ ,  $p = .620$ . Results from the univariate portion of the MANOVA analysis found groups perceptions differed significantly in questions 23, 24, and 26, "How often have you read books about science topics with your friends?", "How often have you talked about science topics with your friends?" and "How often have you worked with science-related hobbies?" These statistically significant results are as follows, respectively:  $F(1, 167) = 5.760$ ,  $p = .018$  ( $\eta^2 = .034$ ),  $F(1, 167) = 4.220$ ,  $p = .042$  ( $\eta^2 = .025$ ) and  $F(1, 167) = 7.084$ ,  $p = .009$  ( $\eta^2 = .041$ ). These results indicate that students in the experienced in HUNCH group more frequently read science books, talked about science, and/or worked on science hobbies than the new to HUNCH group. These results identified small to moderate effects when comparing the new and experienced in HUNCH is explained by their perceptions of interest in HUNCH courses.

Table 22. Descriptive Statistics and MANOVA Results for Comparison of HUNCH Experience by Semester for Interest in Science Questions ( $N= 169$ )

	<i>M</i>	<i>SD</i>	<i>F</i> (1,167)	<i>p</i>	( $\eta^2$ )
19.* How often have you read articles on science-related topics in magazines?					
New	2.476	1.110	2.866	.092	.017
Experienced	2.742	.950			
20.* How often have you read articles on science-related topics in newspapers?					
New	2.353	1.123	.013	.909	.000
Experienced	2.379	.873			
21.* How often have you watched science-related shows on TV?					
New	3.340	1.081	1.170	.281	.007
Experienced	3.515	.899			
22.* How often have you gone to hear people give talks on science?					
New	2.019	1.093	3.803	.053	.023
Experienced	2.349	.903			
23.* How often have you read books about science topics with your friends?					
New	2.223	1.028	5.760	<b>.018</b>	.034
Experienced	2.621	1.004			
24.* How often have you talked about science topics with your friends?					
New	2.825	1.097	4.220	<b>.042</b>	.025
Experienced	3.167	1.090			

Table 22 Continued

25.* How often have you done science projects?					
New	3.461	1.059	1.663	.199	.010
Experienced	3.667	.917			
26.* How often have you worked with science-related hobbies?					
New	3.216	1.114	7.084	<b>.009</b>	.041
Experienced	3.636	.888			

---

*Note.* \* Indicates question was reverse scored

#### Usefulness of Science Classes Comparison

for New and Experienced in HUNCH Groups. The purpose of this section is to

report the results for the differences in SIMSQ responses of students on how they perceive the usefulness of science classes. Table 23 reports the mean scores for the usefulness of science class questions for both the new and experienced in HUNCH groups. The mean scores were derived from averaging the Likert scale numerical values for student responses to questions 27-30. All the SIMSQ questions for this dimension were reverse scored. The mean was used to indicate which group had more positive responses to the usefulness of science classes.

Table 23 presents the descriptive statistics and the univariate ANOVA results from the MANOVA analysis for the four questions in this study that pertain to the usefulness of science classes. The data met the assumptions for the normality of the distribution of the data and equal variances indicating that the MANOVA analysis would be robust for comparing the new and experienced groups across the usefulness of science class questions. Overall results from the one way MANOVA comparing new and

experienced in HUNCH groups across all four relevance of science class questions was not found to be significant, Wilks's  $\Lambda = .390$ ,  $F(4, 160) = .534$ ,  $p = .831$ . Results from the univariate portion of the MANOVA analysis found that group perceptions did not differ significantly on any question. This result suggests that perceptions with regard to the usefulness of science classes explain only a small amount of the difference between new and experienced in HUNCH responses.

Table 23. Descriptive Statistics and MANOVA Results for Comparison of HUNCH Experience by Semester for Usefulness of Science Class Questions ( $N = 169$ )

27. * How often have the things you studied in science classes been relevant to another school subject?	<i>M</i>	<i>SD</i>	<i>F</i> (1,167)	<i>p</i>	( $\eta^2$ )
New	2.970	.984	2.922	.089	.018
Experienced	3.227	.989			
28. * How often have the things you studied in science classes related to things you have learned outside of school?					
New	3.206	.905	3.209	.075	.019
Experienced	3.470	.915			
29. * Science classes are useful?					
New	4.058	.838	1.054	.306	.006
Experienced	4.197	.845			
30. * Much of science classes are useful in everyday life?					
New	3.515	.969	.302	.583	.002
Experienced	3.621	.907			

*Note.* \* Indicates question was reverse scored

### Career Interest in Science Comparison for

#### New and Experienced in HUNCH Groups.

The purpose of this section is to report the results of the differences in SIMSQ responses of students with regard to their career interest in science. Table 24 reports the mean scores for questions regarding career interest in science for both the new and experienced in HUNCH groups. The mean scores were derived from averaging the Likert scale numerical values for each student response for questions 31-35. The higher number chosen, the more students were interested in careers in science. Questions 31, 33, and 34 were reverse scored. The mean was used to indicate which group had a more positive response to a potential career in science.

Table 24 presents the descriptive statistics and the univariate ANOVA results from the MANOVA analysis for the five questions in this study that pertain to career interests in science. The data met the assumptions for the normality of the distribution of the data and equal variances indicating that the MANOVA analysis would be robust for comparing the new and experienced groups across questions regarding career interest in science. Overall results from the one way MANOVA comparing new and experienced in HUNCH groups across all five career interest in science questions was not found to be significant, Wilks's  $\Lambda = .483$ ,  $F(5, 162) = 1.081$ ,  $p = .376$ . Results from the univariate portion of the MANOVA analysis found group perceptions differed significantly on only question 33, "How much do you agree with the statement that I would like to work with people who make discoveries in science?" The statistically significant results for this question were as follows,  $F(1, 167) = 6.788$ ,  $p = .010$  ( $\eta^2 = .039$ ). This result indicates

that students in the experienced in HUNCH group had more positive perceptions of career interest in science than the new to HUNCH group. This result is associated with small to moderate effects for the comparisons made between new and experienced in HUNCH students on items related to their perceptions of career interests in related science.

Table 24. Descriptive Statistics and MANOVA Results for Comparison of HUNCH Experience by Semester for Career Interests in Science Questions ( $N= 169$ )

	<i>M</i>	<i>SD</i>	<i>F</i> (1,167)	<i>p</i>	$\eta^2$
31. * How much do you agree with I would like to be a scientist?					
New	3.184	1.161	1.202	.275	.007
Experienced	3.394	1.288			
32. How much do you agree with I would not like a job in a science laboratory?					
New	3.330	1.106	.076	.784	.000
Experienced	3.379	1.147			
33. * How much do you agree with I would like to work with people who make discoveries in science?					
New	3.524	1.056	6.788	<b>.010</b>	.039
Experienced	3.924	.829			
34.* How much do you agree with a job as a scientist would be interesting?					
New	3.854	1.106	1.637	.203	.010
Experienced	4.061	.875			
35. How much do you agree with a career in science would not be interesting?					
New	3.7184	1.208	.523	.470	.003
Experienced	3.864	1.369			

*Note.* \* Indicates question was reverse scored



### Summary of Results

The MANOVA results indicated that there was a difference in the perception of STEM courses and careers between the new and experienced groups of students. The experienced group predominantly had the more positive perception, though most times it was not statistically significant. The seven questions that were statistically significant are discussed in the following paragraphs.

The first question that was statistically significant was, “How often has HUNCH class made you feel successful?” The construct for self-concept of abilities included this question. It was reverse scored so that the higher the average the more positive the student’s perception of feeling successful in HUNCH class. Experienced in HUNCH students indicated a more positive perception than the new to HUNCH students.

The statistically significant questions that apply to students’ perceptions of the ability to make choices were, “How often have you chosen the topic or project yourself for HUNCH class?” and “How often have you had the chance to work at your own pace?” Both of these questions were reverse scored so that the higher the average the more positive the student perceptions of their ability to make choices in HUNCH class. Experienced in HUNCH students indicated a more positive perception than new to HUNCH students.

There were three questions designed to assess the construction of interest in science that the new to HUNCH and experienced to HUNCH students expressed significantly different perceptions. The questions asked how often students read books, talked about science, and worked on science related hobbies. The results from the SIMSQ

indicated that the experienced in HUNCH students rated their perceptions of interest in reading and talking about science as well as having science related hobbies significantly higher than the new to HUNCH students.

The seventh statistically significant question asked about students' interest in working with people who made discoveries. This was the only statistically significant question in the construct of career interest in the SIMSQ. This question was reverse scored so that the higher the average the more positive the student's perception of the desire to work with people who made discoveries. Experienced in HUNCH students indicated a more positive perception than the new to HUNCH students.

In summary, the results of the SIMSQ indicated that student perceptions in all of the questions were more positive overall for the experienced in HUNCH students. Seven of these questions were statistically significant, which came from five of the constructs that the SIMSQ analyzed.

### Trustworthiness of Results

This research used four indicators to show evidence of trustworthiness. These strategies are credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985). Without evidence of trustworthiness, the results are not well substantiated. The mixed-methods approach used for this study enhanced the trustworthiness of the results because it required multiple data collection methods and analyses to verify the accuracy of the outcomes. Each of the four strategies employed several important criteria to support the trustworthiness of the results. Triangulation is often used to show evidence of credibility, transferability, dependability, and confirmability by collecting, analyzing

and comparing outcomes from multiple data sources that supports the credibility, transferability, dependability and confirmability of the results (Lincoln & Guba, 1985). Evidence collected to support the trustworthiness of the study outcomes is discussed in the following section.

The criteria for credibility involved triangulation, establishing authority of the researcher, and reflexivity. Triangulation of the quantitative results from the SIMSQ, focus groups, and individual student interviews was the main method for establishing trustworthiness, but not the only one. The authority of the researcher is also considered important for meeting the criteria of trustworthiness. Evidence to support the researcher's authority was supported by her professional affiliations with the HUNCH program. First, she was a HUNCH teacher, in which her high school students were tasked with building hardware for NASA. In this role, the researcher received a deep understanding of how the HUNCH program affected her students. Second, the researcher spent two weeks visiting other HUNCH schools to gain insight on how other HUNCH students perceived HUNCH classes. Finally, the researcher is presently employed as the HUNCH Project Manager of the National Laboratory Program, in which she mentors schools on the design of experiments proposed to fly on the Zero-Gravity plane.

The reflective journal entries that the researcher recorded during her two week trip to HUNCH schools in Texas, Alabama, and Tennessee was also used to support the credibility of this study. Her journal entries included detailed descriptions of the students, their schools, and the overarching themes emerging from focus group interviews. The journal was an important source of information that could be used to confirm outcomes

that emerged across data collection methods. The data obtained from interviews, the SMISQ and school data-bases provided the information that the researcher used to write in-depth descriptions of the research contexts for this study. These detailed descriptions are important to readers of this research who evaluate the outcomes of this research relative to other similar contexts.

Transferability contributes to this study's trustworthiness because the in-depth descriptions of the research context allow readers to make more accurate generalizations of results related to how they might apply to similar programs in other schools. In this research, transferability or generalization of results is limited to schools with similar demographic and contextual attributes that are similar to the HUNCH schools that were investigated by this study. An in-depth description of the schools participating in this study is included in Chapter 3.

Evidence for the dependability of this research is documented was the dense description of research methods, code-recode procedures, and triangulation methods. An in-depth description of the quantitative and qualitative methods used is provided to facilitate future replications of this study. The SIMSQ is more easily replicated than the focus groups and interviews, because the SIMSQ questionnaire can be easily replicated and administered to students. Chapter 3, Appendix E, and Appendix H includes detailed descriptions of the procedures, along with questions asked in the SIMSQ, focus groups, and interviews.

Evidence to support the dependability of the study is described by the procedures the researcher used when employing the code-recode procedures for constant comparison

of themes that were identified from individual and focus group interviews. The focus and individual student interview results were constantly compared using the code-recode method to identify subthemes that contributed to identifying the overall overarching themes. This constant comparison method increased the dependability of results because the analysis of the similarities and differences among the themes allowed for the reconciliation of results that lead to the identification of the overarching themes across participant interviews.

The remaining characteristic contributing to the trustworthiness of this study is confirmability. Confirmability is similar to objectivity and required the researcher to reflect on how her biases influenced the researcher's interpretations of the outcomes of the study (Creswell, 2002). In this study, the researcher constantly maintained an awareness of her biases and tried to remain as objective as possible when identifying, analyzing and interpreting quantitative data collected for this study. During the focus groups and interviews, the researcher maintained an awareness of her perspective and made a conscious effort not to influence the student interview responses.

### Triangulation of Quantitative and Qualitative Results from SIMSQ, Focus Groups, and Interviews

#### Introduction

The final section of this chapter links the results between the SIMSQ, focus groups, and individual student interviews. The use of methodological triangulation by the mixed-method approach increased the trustworthiness of the quantitative and qualitative results. The triangulation of the results discussed in this section was summarized in Table

25. Table 25 has the themes listed in order of prominence judged by the researcher as a result of all the criteria applied to trustworthiness.

Table 25. Summary of Triangulation of Results from SIMSQ, Focus Groups, and Interviews

<i>Theme</i>	<i>Results from SIMSQ</i>	<i>Results from Focus Groups</i>	<i>Results from Interviews</i>
Hands-on Nature of STEM HUNCH classes	Students indicated that they liked to go to science laboratory classes, which are more hands-on than regular science classes	Students indicated that they enjoyed and learned best while doing hands-on projects that involved tasks that most people would not consider fun	Students indicated they excelled in hands-on work that involved unique skills
Enjoyment of STEM HUNCH classes	Students had a positive perception of enjoying STEM HUNCH classes. The greater percentage of students were not bored and they viewed class as fun	Students indicated that STEM HUNCH classes were fun and a reason they liked to go to school	Students indicated that STEM HUNCH classes were cool
Self-Concept of Abilities in STEM HUNCH classes	Students indicated they were confident and successful in HUNCH class	Students indicated a very positive attitude toward their abilities in math, science and computers	Students indicated a very positive attitude toward their abilities in STEM areas
Lack of Anxiety in STEM HUNCH classes	Students indicated they felt able to understand their work and were comfortable in HUNCH class	Students were less stressed in HUNCH classes because mistakes were viewed as learning opportunities and they had fewer deadlines to meet	Students were less stressed in HUNCH classes because of their above average abilities in the STEM areas and their confidence to do well

Table 25 Continued

Challenging Nature of STEM HUNCH classes	23.8% of students said that their work in STEM HUNCH classes is <i>never or seldom</i> too easy	Students indicated that they pay attention to challenging projects and like to think outside the box	Students indicated that they enjoyed challenging projects
Student-centered Learning in STEM HUNCH classes	Students had positive perceptions of their ability to choose their projects and to work at their own pace	Students had positive perceptions of being able to work on their own or within small groups and to solve problems their own way with the teacher acting as a facilitator	Students indicated that they liked to figure things out for themselves
Relevance of STEM HUNCH classes	Students indicated a positive perception of STEM HUNCH classes as useful and relevant	Students indicated that they applied their math and science learning in STEM HUNCH classes and that working for NASA was important	Students had a positive perception of the usefulness and relevance of STEM HUNCH classes, especially to their future goals
Career Interest in STEM areas	Students indicated they had a positive perception of working with people who make discoveries	The greatest percentage of students wanted to go into STEM careers	All the students interviewed wanted to go into STEM careers
Influence of Others	NA	Family, friends and teachers influenced students' positive perceptions of STEM careers	Family, friends and teachers influenced students' perceptions of STEM careers
Exposure to STEM HUNCH courses on Career Choices in STEM areas	NA	Without the exposure to STEM HUNCH courses students would not have been interested in STEM careers	Students indicated that exposure to STEM HUNCH courses promoted their interest in STEM careers

Triangulation of results occurred when all three sources of data converged to identify prominent themes. hands-on learning, enjoyment of classes, self-concept of abilities in STEM areas, lack of anxiety in classes, challenging nature of the work, student-centered learning, relevance of classes, career interest in STEM areas, influence of others, and exposure to STEM classes. For example, the quantitative results from the SIMSQ indicated that HUNCH students enjoyed HUNCH STEM classes and both the students in the focus groups and individual student interviews also mentioned their enjoyment of HUNCH STEM classes. These emergent themes are discussed in the following sections. The themes listed are in order of prominence as judged by the frequency of the mentioned perceptions that were indicated in the SIMSQ, focus groups, and interviews.

Hands-on Learning. The most frequently mentioned emergent theme from focus groups and interviews was that students indicated they learned best by doing or building projects with their hands. Students frequently talked about the hands-on nature of the STEM HUNCH classes. Participants indicated that they excelled in hands-on work when compared to book learning. The results from the SIMSQ did not directly ask about student perceptions of hands-on work. However, it did ask if students liked to go to science laboratory, which is usually hands-on. Almost all of the students (64.2%) indicated that they *often* or *always* liked to go to science laboratory classes.

Enjoyment of Learning. Results for the construct of enjoyment of STEM HUNCH courses indicated strong positive perceptions of student enjoyment of STEM HUNCH



classes. The SIMSQ had a strong positive response to classes being fun and almost never boring. Students in the focus groups frequently mentioned that the STEM HUNCH classes were fun. In the focus groups and interviews, students often mentioned the “cool” nature of the STEM HUNCH work. They often called their classes “cool” or “fun,” which were not two adjectives that they used frequently to describe their regular classes. Students often indicated that their STEM HUNCH class was the reason they liked going to school.

Self-Concept of Abilities. The quantitative and qualitative results indicated that self-concept of ability in STEM areas was certainly a construct where the results of the quantitative data and qualitative data supported one another. This theme was prominent in the SIMSQ, focus groups, and individual student interviews. Students indicated positive self-perceptions on SIMSQ questions dealing with their confidence and success in STEM HUNCH classes. For the question, “How often has HUNCH class has made you feel successful?” 82.0% of the students responded *always* or *often*. Students in the focus groups and interviews often mentioned their natural ability in STEM areas. Most students said that they were good in mathematics, science, and/or computers. Students realized that they were better than the average student in STEM areas.

Lack of Anxiety. The results of the SIMSQ indicated that students were not unhappy or uncomfortable in STEM HUNCH classes. In fact, the construct for lack of anxiety in STEM HUNCH classes received the highest positive student perception of all the constructs measured by the SIMSQ. Triangulation occurred with the agreement

between the SIMSQ, focus groups, and individual student interviews for students' perception that there was a lack of anxiety in STEM HUNCH courses.

Students in focus groups indicated that STEM HUNCH courses were less stressful than regular science and mathematics courses. This was predominantly due to mistakes in HUNCH classes being viewed as learning opportunities and because of the lack of daily homework assignments and deadlines. Students in the interviews indicated they were less stressed in HUNCH classes than in regular classes, but their reason involved their confidence that they would succeed in STEM HUNCH classes.

Challenging Work. One of the reasons that students indicated that STEM HUNCH classes were enjoyable was because they were challenging. The challenging nature of the work was mentioned by all the focus groups and interviewees as a positive attribute of STEM HUNCH classes. Students often discussed how the challenging nature of the work required them to pay close attention in class. Students also mentioned that they enjoyed the challenge of problem-solving and thinking outside the box. However, the SIMSQ did not directly ask a question about how students perceived challenging work. The SIMSQ did ask if the class was too easy and over 23% of the students indicated *never or seldom*.

Student-Centered Environment. Students indicated that being able to solve problems their own way instead of being given step-by-step instructions was the best way for them to learn. Students liked being able to learn from each other and enjoyed working in small groups. Students in the focus groups indicated that they did not like worksheets

or busy work at their desks, which they said was routine in many regular classes. The SIMSQ's questions about the ability of students to make choices in STEM HUNCH classes related to the theme of a student-centered environment, because most students indicated that having choices and being able to work at their own pace was a positive attribute of HUNCH classes. A majority of students in the focus groups and all of the interviewees spoke about the role of the teacher as a facilitator in the STEM HUNCH classroom, which they mentioned as a positive attribute of HUNCH classes. Students indicated that they learned best when they figure things out for themselves, but they did appreciate a knowledgeable instructor who could be a guide or "captain."

Relevance of Learning. Results on the relevance and usefulness of STEM HUNCH classes were connected by students' positive perceptions from the SIMSQ, focus groups, and individual student interview results. The SIMSQ results indicated that students perceived STEM HUNCH classes as relevant and useful. This result was supported by themes emerging from focus group and individual interviews where students often expressed how they were able to apply their math and science learning to HUNCH projects. Students also indicated that their learning in STEM HUNCH classes was applicable to their future educational and career goals. Students indicated that building projects that were going to be used by NASA meant a lot more than building a project just for a grade. The students that were interviewed particularly indicated that their HUNCH work was useful and relevant to their future goals.

Career Interest. The results from the SIMSQ, focus groups, and individual student interviews all indicated a positive perception toward career interest in STEM areas. The last five questions on the SIMSQ dealt with students' interest to become a scientist. The results of the SIMSQ showed that students had the strongest positive perception with regard to the question that addressed working with people who make discoveries. Students in the focus groups and the interviews indicated that their future career goals were vital to their motivation to learn in class. When the STEM HUNCH class involved their future career goals, then the students wanted to learn as much as possible from that class. Many of the HUNCH students wanted to go into STEM careers. HUNCH teachers believed that 69% of their past HUNCH students entered post-secondary education with the intent to continue studying STEM areas.

The Influence of Others and Exposure to STEM Classes. Triangulation of quantitative and qualitative results did not occur for these two themes because the SIMSQ did not have a question relating to them. However, these themes were mentioned so frequently during the focus groups and interviews that the researcher felt they needed to be included in this section.

Influence of Others. Students in focus groups and interviewees discussed their interest in STEM areas, which often developed because of their exposure to friends, family, and teachers who were in STEM professions. These students indicated that knowing or working with others that were engineers or STEM professionals often

increased their interest in these areas. The SIMSQ did not have any questions that addressed this theme.

Exposure to STEM Classes. Students in the focus groups and interviews indicated that STEM HUNCH courses had a positive influence on their career choices in STEM areas. For example, some students expressed during interviews that they did not understand the work of an engineer until they enrolled in a STEM HUNCH class. Students also commented that STEM HUNCH courses were proving grounds to determine if they had the ability and interest to pursue STEM careers. The SIMSQ did not have any questions that addressed this theme.

### Summary

The trustworthiness of this study's outcomes was established with the alignment of results from SIMSQ, focus group, and individual student interview results. The SIMSQ results indicated that the students have positive perceptions of their STEM HUNCH classes as being fun and interesting. This was indicated by students in both the focus groups and interviews. The SIMSQ results indicated that students felt confident and successful in their STEM HUNCH classes, which aligns well with student comments in focus groups and individual student interviews. The SIMSQ results indicated a positive student perception of abilities to understand and feel comfortable in STEM HUNCH classes. Students indicated this same sense of understanding and comfort in HUNCH classes in their focus groups and individual student interviews. The SIMSQ results

indicated that students in STEM HUNCH class felt they had opportunities to choose their topics and work at their own pace.

Students in the focus groups and individual student interviews often mentioned the importance of their ability to choose their work in STEM HUNCH class. The SIMSQ results indicated that students had a positive perception of the relevance and usefulness of their learning, which was also indicated by the students in the focus groups and individual student interviews. The SIMSQ results indicated that students were particularly interested in working with people who made discoveries. This outcome was substantiated by students in the focus groups and individual student interviews and the teacher survey, in which the great majority of students wanted to enter STEM careers. Both quantitative and qualitative results support the claims that HUNCH students preferred classroom practices that allowed for the enjoyment of learning, specifically the practice of hands-on learning, and challenging authentic projects that not only applied their learning in the traditional STEM classrooms, but also promoted a deeper understanding of the theoretical concepts.

## CHAPTER FIVE

## CONCLUSIONS

Introduction

This study was undertaken to identify classroom practices that motivate students to study and pursue STEM coursework and careers. The idea for this topic originated because of my background as a former HUNCH teacher. During my time as a HUNCH teacher, I saw an incredible change in my HUNCH students' attitudes toward STEM courses and careers. I felt that it was critical to identify why HUNCH students' attitudes were changing as well as to document the HUNCH activities.

Promoting STEM education and careers should become a national priority if the United States is to maintain its position as the premier global technological innovator. In fact, President Obama in his State of the Union 2011 address to the nation has called for educational reform, especially in STEM areas. The HUNCH program is one example of an innovative school-based program that is aligned with the type of educational reform that President Obama and others have recommended. Although, programs like HUNCH have been recommended as one approach for teaching STEM concepts and skills, there is a lack of research which identifies the components of these programs that contribute to student proficiencies and interest in STEM coursework and careers.

Program evaluations of school-based programs have generally found that programs similar to HUNCH, which engage students in hands-on activities, especially when tied to challenging content and opportunities to solve meaningful problems, have a

positive influence on student interest in STEM coursework and careers (e.g., Goodman, 2006; Walcerx, 2007; Bottoms & Uhn, 2007). However, none of these studies investigated or identified the specific motivational constructs across the learning spectrum that were found to have the most influence on student interest in STEM coursework and careers. The purpose of this mixed-method descriptive study was to identify the learning experiences from the HUNCH program that influenced students' motivation to study and pursue careers in STEM areas. This research provides data on student perceptions of classroom practices and the learning experiences that motivate them in STEM areas. With this knowledge, best practices can be incorporated into other school-based programs designed to promote student learning in STEM coursework and related careers. Knowledge gained from this study aids schools, businesses, and agencies that want to expand or develop new innovative school-based programs to motivate students in STEM areas. Because of the aforementioned national priority being placed on STEM education, new programs that seek to promote STEM education are developing rapidly. It is hoped that this research will help in their successful implementation.

### Research Questions

This research study investigated the influence of NASA's HUNCH program on student perceptions of STEM coursework and careers. The HUNCH curriculum is designed to engage students in authentic activities that involve science, technology, engineering, and mathematics skills. An overarching goal of the HUNCH program is to



use these authentic experiences to promote student interest in STEM coursework and careers.

This research study examined student perceptions of classroom practices of the HUNCH program. The students were asked to comment on the impact the HUNCH program had with regard to their desire to study and pursue careers in STEM areas. The results from this research answer the following four questions:

- (1) How do students who participate in HUNCH programs perceive STEM HUNCH courses and other STEM courses?
- (2) How do students who participate in HUNCH programs perceive STEM related careers?
- (3) What learning experiences do HUNCH students describe as motivating them toward pursuing courses and careers in STEM areas?
- (4) Do students who have fewer than two semesters in HUNCH perceive STEM related courses and careers differently than students who have participated in three or more semesters in HUNCH?

### Findings

#### Research Question 1: How do Students Who Participate in HUNCH Programs Perceive STEM HUNCH Courses and Other STEM Courses?

Research question 1 was answered from student responses to questions 1-30 of the SIMSQ (Appendix H), results from student focus groups, and individual student interviews. The quantitative and qualitative results both indicated that HUNCH students have positive perceptions of STEM courses. All constructs measured on the SIMSQ had at least a majority of the students indicating positive perceptions.

Enjoyment, usefulness, and the relevance of learning, in addition to student self-concept of ability were constructs assessed by the SIMSQ and also were themes that emerged from student focus groups and individual student interviews. These constructs have also been identified by previous research investigating factors hypothesized to enhance student learning in science and other STEM related content (Barmby et al., 2008; Kohn, 2005; Osborne et al., 2003; Reiss, 2004).

The qualitative data added depth and understanding to the quantitative data collected from student responses to the SIMSQ. For example, while results from the SIMSQ highlighted enjoyment of learning as an important factor related to student interest in science, the focus groups and individual student interviews further revealed that their enjoyment of learning was related to working with peers and STEM professionals when engaged in hands-on instructional activities that involve authentic and challenging problem-solving tasks. In addition to enjoyment of learning, analysis of data from the focus groups and individual student interviews revealed that the application of learning, relevance of learning, and self-confidence in science ability were other factors that contributed to their interest in science and other STEM related courses.

The themes related to the enjoyment of learning that emerged from this study is similar to that reported in research conducted by Barmby et al. (2008) which found that students' enjoyment of learning was an influential factor in motivating student interest in science content. Moreover, as was found from analysis of focus groups and individual student interviews, other researchers also found that instructional approaches such as the use of challenging hands-on investigations was important for enhancing students' interest

in science (Barmby et al., 2008; Stipek & Seal, 2001). Findings from this research are further aligned with research by Osborne et al. (2003) which concluded that students' enjoyment of learning decreased as the amount of seat work and rote memorization increased in science courses.

HUNCH students indicated that they did not enjoy classroom practices that involved seat work or rote memorization of course concepts. However, when asked about their learning experiences, HUNCH students indicated that they not only enjoyed the STEM HUNCH classes, but also learned best when working with hands-on projects. This finding supports propositions by learning theorists such as Keller (2000) and Csikszentmihalyi (1990) who suggest that learning is enhanced when students are engaged in learning experiences that they perceive to be enjoyable.

The use of challenging projects to teach STEM concepts was also identified by students as contributing to their enjoyment of learning when enrolled in HUNCH courses. Vygotsky's Zone of Proximal Development and Weiner's attribution theory indicate that learning occurs best when it is not too easy or too difficult, but rather challenging enough to be achievable with scaffolding by instructors. Motivational learning researchers often discuss the lack of anxiety at the Zone of Proximal Development, because of the ability of students to succeed (Lee, 2003; Stipek, 2002; Tobias, 1979). However, this research found that learning at the Zone of Proximal Development also leads to enjoyment. HUNCH students enjoyed learning at the level where they were challenged, but still successful.

Results from this study also suggest that learning was more enjoyable when students could learn from each other. Students indicated that they felt they learned best when fabricating projects, while working in cooperative, peer groups. This classroom practice, along with the classroom practice of providing students with opportunities to make choices, added to student enjoyment in STEM HUNCH classes. Students stated that working with others especially on topics of their choice was much more enjoyable and a better way for them to learn than sitting at a desk and working by themselves. These findings are aligned with situational learning theorists such as Lave and Wenger (1991) who propose that learning is understood best when it takes place in an environment where all students are valued and able to make decisions.

Learning theorists generally agree that learning should be enjoyable (Keller, 2000; Stipek & Seal, 2001; Barmby et al., 2008; Csikszentmihalyi, 1990). Researchers suggest that learning environments that students find enjoyable are those that include hands-on experiences, within student-centered classrooms, where students of all levels and STEM professionals work together on authentic tasks (Park, 2006; Lave & Wenger, 1991). Worksheets replaced by hands-on projects, and lectures replaced by student-centered classrooms where students were given opportunities to collaborate, think, and create were identified by students as contributing to the enjoyment of their HUNCH classes and the study of STEM content.

Research in the field of relevance as it relates to learning also indicates its importance in motivation of learning (Kember et al., 2008; Benware & Deci, 1984; Shih, 2008). An outcome related to HUNCH student perceptions of STEM HUNCH courses

was the satisfaction that students derived from completing a valued task successfully. It was equally important for HUNCH students to know that what they were accomplishing in class was valued by NASA. HUNCH students mentioned that a project built for NASA was a more meaningful activity to them than a project just to earn a letter grade.

Student perceptions of the practical applications of concepts have been identified by prior research as related to positive attitudes toward learning. The research of Kember et al. (2008), Benware & Deci, (1984), and Shih (2008) all found that the more positive student perceptions were with regard to the usefulness and relevance of the knowledge they learned, the more likely they were to engage in learning tasks. This finding from prior research is supported by general comments from HUNCH students who indicated that they were more interested in learning when provided with a reason to learn. The relationship between perceptions of usefulness and relevance to positive attitudes toward learning was also supported by findings from this study. This research found that HUNCH students worked particularly hard to be successful when they believed the HUNCH projects were useful to NASA. Students indicated that when provided with a reason to learn, they were more motivated to succeed at the learning.

Research by Bandura (1997) and Keller (2000) suggests that students who feel confident in their ability to succeed are more likely to complete learning tasks and reach higher levels of achievement. HUNCH students who perceived that their skills in science, technology, engineering, and mathematics were above average, felt confident in their ability to succeed in STEM HUNCH classes. Students' positive perceptions of their science and mathematics abilities suggest that they most likely learned to feel more

confident in their STEM HUNCH classes than in other academic classroom settings.

Many students felt that they had natural abilities in skill sets related to STEM coursework and felt that concepts in STEM areas were easier to learn in comparison to other subjects such as English or History.

Table 15 shows that over 80% of HUNCH students indicated that much of science classes were *always*, *often* or *sometimes* useful in everyday life. The results supports the argument that student participation in the HUNCH program enhanced their understanding of the usefulness of science. Students in HUNCH programs indicated that it was important to their understanding of STEM concepts to know the application or usefulness of their knowledge. In STEM HUNCH classes, students often applied and learned a concept simultaneously, which students indicated added depth of understanding to their knowledge. The work of Lave and Wenger (1991) substantiates the notion that students learn best when learning takes place within its authentic applications.

The results from both the quantitative and qualitative research indicated that students perceived STEM HUNCH classes as enjoyable, challenging, useful, and relevant. The results further suggest that these positive perceptions were instrumental in motivating students to engage and perform at highly proficient levels in the HUNCH activities that are infused into the STEM curricula.

#### Research Question 2: How do Students Who Participate in HUNCH Programs Perceive STEM Careers?

Research question 2 was answered from student responses to questions 31-35 of the SIMSQ (Appendix H), as well as results from student focus groups, individual

student interviews, and teacher surveys. The quantitative and qualitative results indicated that the majority of HUNCH students have positive perceptions of STEM careers.

Results from the SIMSQ found that 47.0% of HUNCH students *strongly agreed* or *agreed* that a career in science would be interesting. In addition, results from focus groups and individual student interviews indicated that HUNCH students were interested in a number of engineering careers ranging from mechanical to aeronautical engineering. The SIMSQ results indicated that HUNCH students had a strong interest in working with people who make discoveries (66.9%), while only a moderate interest in being a scientist (47.0%). Further support for HUNCH students' avid interest in STEM courses and careers was supported by HUNCH teachers who reported that 69% of their past HUNCH students enrolled in post-secondary programs related to a variety of STEM careers. Many of the HUNCH students also expressed interest in pursuing a variety of technical trade careers related to servicing and repairing automobiles, computers, and electronics. This interest in STEM areas other than "pure science" may provide insight into why there were mixed results in the SIMSQ questions that were written to assess career interests in science.

In this study, there were a number of HUNCH students who indicated that they changed their career goals for example from auto mechanics, machinists or lawyers to engineering. This trend seemed to be the result of student exposure to the work of engineers. Students indicated that they became interested in engineering by being exposed to engineers, the work of engineers, as well as by gaining the self-confidence that they could do the work of engineers. The use of professionals employed in STEM

careers is an important consideration when designing STEM coursework that motivates students to pursue engineering and other STEM related careers.

Two motivational factors that influence student interest in STEM areas identified by this research are the influence of family and friends and exposure to STEM professionals. These emergent themes were identified through student focus groups and individual student interviews. It is hypothesized that one reason that students expressed positive perceptions and were motivated to pursue STEM related careers was the influence of family and friends. Students spoke freely about how their parents' STEM involvement influenced their career goals. One unique aspect of this research was that most of the participants came from communities around Johnson Space Center or Marshall Space Flight Center. Not only does NASA have a huge presence in these communities, but also some of the largest technology companies in this country have offices located in these communities (the only exception to this occurrence were participants from Laurel High School in Laurel, Montana). Students whose family members worked in STEM careers received exposure to these fields at an early age. They grew up knowing about the work of STEM professionals. That was the situation for many participants, but not all. The fact that participants and their families lived in communities that were connected professionally to NASA and affiliated industries may be one reason that the influence of family and STEM professionals emerged as a prominent theme. Future research on the influence of family and friends on STEM career choices is merited. The question arises on how the HUNCH program and other innovative school-based programs can reach out to communities a long distance from NASA or other



technological STEM industries. If the goal of NASA is to increase the quantity, quality and diversity of students entering STEM areas, then further research on this question is important.

This study did not investigate factors that are likely to increase the gender and social economic status diversity of HUNCH participants. Only 27 out of 169 HUNCH participants in this study were female and the social economic status (SES) of its participants was not surveyed. However, an important question that must be asked is how the HUNCH program or other innovative school-based programs can increase the diversity of its participants. The one female student interviewed had been exposed to STEM professionals, since she was young. She indicated how this did influence her career choice. She knew she wanted to be an aerospace engineer and to help reach this goal she not only was willing to transfer to another school in her district, but also take machine shop. This girl's experiences suggest that further research be conducted to examine the influence of female STEM role models on female motivation toward pursuing STEM coursework and careers. One way to accomplish this goal may be to extend HUNCH into high school courses that traditionally have more female students. In 2009, the HUNCH program was incorporated into courses such as family and consumer science, fashion design, forensics, TV and video production, and environmental classes. For these courses the HUNCH program expanded its activities into fabrication of soft goods such as cargo transfer bags, videos, and science experiments. However, in this study research was not conducted to identify the difference in factors that motivated male and female interests in STEM related courses and careers.

From the very beginning, the HUNCH program was designed to reach out to a greater diversity of students in hopes to inspire and engage them in professional STEM careers. Initially, the HUNCH program was implemented with career and vocational courses, where students did not normally seek engineering careers. An important outcome of this research was that students enrolled in HUNCH coursework who were primarily interested in machine and auto shop careers become interested in pursuing careers in engineering. These particular HUNCH students and others in this study indicated that their exposure to engineering work, and their increase in self-confidence in their abilities to succeed at STEM related coursework, motivated them to pursue careers in engineering. This outcome suggests that expanding HUNCH activities into science, mathematics, technology and engineering courses may help to increase the interest of a diverse group of students who would be motivated to pursue STEM careers, or to consider work in previously unfamiliar STEM fields such as engineering.

The interaction of students with STEM professionals was a motivational practice attributed to the HUNCH curriculum that emerged from this research. As with the influence of family and friends, it was felt that student interactions with STEM professionals had positive effects on student attitudes toward STEM courses and careers. Some HUNCH students' first exposure to STEM careers was during their interactions with teachers and other professionals such as engineers and scientists during STEM HUNCH classroom activities. One such student indicated that he did not think science would play a role in his career goals, until being enrolled in a HUNCH class. It was within that class that he was able to form a positive perception of engineering as a career.

Another student indicated that he did not even realize he had talent in drafting until he enrolled, by chance, in a drafting class. Still another student said that she wanted to be a lawyer, until her exposure to a STEM HUNCH class, and now she wants to be an engineer. Students have to have exposure to STEM careers in order to form an opinion of them. The results of this research indicated that providing opportunities for allowing high school students to interact with professionals in STEM related careers positively impacted student perceptions of STEM careers. Scientific and technological companies are expanding their partnerships with public schools through their involvement with STEM classrooms in an effort to increase student interest in STEM careers. However, with the exception of results from this study, there is little documented evidence to support the effects of the relationship between corporate partnerships and students' interest in STEM careers.

Organizations that depend on scientists, technicians, engineers, and mathematicians have a huge stake in promoting STEM careers, because they are in need of a future work force. The STEM HUNCH professionals that partner with schools that use the HUNCH curriculum provide important mentoring relationships, and offer an incredible source of knowledge and enthusiasm that contribute to young people's positive perceptions of STEM careers. Results from this research suggest that schools engaging in partnerships with STEM businesses may be a productive approach for promoting positive student perceptions of STEM careers and increase the likelihood that students will pursue STEM related occupations.

Research Question 3: What Learning Experiences  
do HUNCH Students Describe as Motivating Them  
Toward Pursuing Courses and Careers in STEM Areas?

Analysis of HUNCH student responses from focus group interviews and individual student interviews acknowledged five previously identified factors that research suggests motivates toward the pursuit of STEM coursework and increases their interest in STEM careers. Results from focus groups and individual interviews found that hands-on, relevant learning activities that were challenging without causing excessive anxiety were identified by HUNCH students as motivating.

The hands-on nature of STEM HUNCH projects was the most frequently mentioned characteristic that students identified as responsible for motivating them to pursue additional STEM coursework and careers. Prior research by Park (2006) suggests that some hands-on projects used as instructional activities often involve the use of lock-step instructions rather than student-centered, open-ended activities designed to support inquiry-based instruction. This research found that students had a better understanding of STEM concepts when HUNCH learning activities designed to teach abstract concepts were hands-on and viewed as authentic and important. Furthermore, HUNCH students were motivated by feelings of self-confidence as a result of knowing that it was their efforts that resulted in solving the many problems that just pop up when hands-on activities involved fabricating hardware for NASA.

Research by Hake (1998) investigated the use of differences in interactive-engagement to teach physics. Results from his research found that high school physics students' who were taught using an interactive-engaged approach scored significantly

higher on measures of conceptual understanding than high school physics students who were taught with more traditional and less interactive methods. Research by Cobern, Schuster, and Adams (2010) suggests that the influence on student's understanding physics concepts may be due to the use of problem-solving skills specific to science that are used during inquiry-based learning activities. Direct instructional practices often approach science instruction as a body of facts to be learned through memorization rather than using learning facts within the context of scientific process of thinking required to solve complex, authentic problems (Alberts, 2009).

Students indicated that they learned best by collaborating with peers, teachers, and mentors through discussions prompted by questions related to the knowledge and skills required to solve problems necessary to complete course projects. Teachers, students, and classroom mentors formed a student-centered classroom, in which each contributed to the project according to their own level of abilities. This happened frequently in STEM HUNCH classes, because new HUNCH students' were frequently placed into classes with existing HUNCH students in the same classroom. For example, drafting students I and II were in the same class. The more experienced HUNCH students were available and ready to assist new students. This allowed for a classroom environment where everyone was valued and everyone contributed according to their individual abilities. HUNCH students were motivated to complete their course work, even when they fell behind, because of the responsibility they shared with peers and mentors for completing course projects.

This situation fostered the growth of student-centered classrooms, which research suggests is important for learning STEM related concepts (Palincsar, 1989). This collaborative learning environment was also thought to be instrumental in promoting student interest in STEM HUNCH courses. STEM HUNCH classes were established within the context of collaborative projects that engaged students in authentic, real-world, complex activities that promoted the types of environments that Lave and Wenger (1991), Wineburg (1989), Collins et al. (1991), and Brown et al. (1989) suggest are required for meaningful learning.

Students also explained that in HUNCH activities, they gained a better understanding of STEM concepts. This finding is supported by the research of others. Wineburg (1989) wrote, “Knowledge is not free-floating but situated in activity” (Wineburg, 1989, p. 8). His notion of situated learning was clearly found within STEM HUNCH classes. Many educational researchers suggest that learning needs to be embedded in authentic activities for students to achieve the best understanding of the material and for them to be able to transfer their learning to real-world problems (Lave & Wenger, 1991; Collins et al., 1991; Wineburg, 1998). In some traditional STEM classrooms, learning is positioned within a purely academic scenario rather than a practical or applied setting. For example, students are taught to solve equations within a purely mathematical context rather than one in which the problem-solving activity is related to authentic contexts that tap student’s prior experiences. HUNCH classes on the other hand are elective and are not constrained by the narrowing of the curriculum imposed by content standards that drive instruction for traditional STEM courses.

Outcomes from this research supporting the use of authentic, hands-on instructional activities for enhancing student interest and learning in science are supported by Brown et al. (1989) research, which suggests that traditional STEM courses incorporate authentic, problem-solving activities that support intuitive reasoning, discovery learning, and decision-making to enhance engagement and learning.

Another learning experience that HUNCH students indicated as a motivating factor for them to pursue STEM courses and careers was the lack of anxiety they felt in STEM HUNCH classrooms as compared to some traditional STEM courses such as physics and mathematics. Although working for a high profile government agency such as NASA might be anxiety provoking, students indicated that they were more relaxed in STEM HUNCH classes, because they were involved in student-centered tasks where teachers collaborated with students to learn STEM concepts related to the construction of NASA hardware.

There is ample research on how stress affects learning (Corbett et al., 2008; Chinn, 2008; Jain & Dowson, 2009; Tobias, 1979). The literature suggests that low levels of stress may be beneficial for motivating student learning, while larger amounts of stress have adverse effects on student performance (Tobias, 1979). The fact that students expressed that they perceived their stress to be low during STEM HUNCH classes suggests they were better able to focus on the learning activities without fear of failure.

Another positive aspect of STEM HUNCH classes that motivated students to perform was the manner in which teachers viewed mistakes. In traditionally taught science and mathematics classes, mistakes are often viewed as failure rather than part of

the learning process. In STEM HUNCH classes, failure was not an option and mistakes were not viewed as failure, but as learning opportunities. HUNCH students indicated that they did make mistakes, but that teachers used their mistakes to support learning rather than as an indicator of poor performance in terms of a letter grade.

The use of daily due dates for assignments that students expressed characterized some traditional STEM classes was another source of stress identified by students. Generally science and mathematics classes frequently required students to submit assignments on a daily basis. On the other hand, it was not unusual for projects in STEM HUNCH classes to take several months or sometimes the entire school year to complete. Students found this classroom arrangement appealing because their learning was flexible and not bounded by routine deadlines that impede learning and deeper understanding.

The way in which failure was viewed by students indicates that HUNCH teachers and mentors must have made conscious efforts to build feelings of success. Viewing mistakes not as failures but as learning opportunities was implemented in the fabrication of HUNCH projects. Hale indicated that HUNCH supplies schools with a third more material than needed for their projects, because students will need the extra material to complete the projects successfully (S. Hale, personal communication, March 10, 2010). Research suggests that when teachers view mistakes as learning opportunities, students are more motivated to complete tasks resulting in greater knowledge and understanding of concepts (Hulleman & Harackiewicz, 2009; Keller, 2000; Bandura, 1997). When Edison was trying to invent the light bulb, after his 300<sup>th</sup> time someone said, “Aren’t you



discouraged?” He said, “No I’m happy because I just found one more way that it doesn’t work.”

The final theme that emerged dealt with the relevance of STEM HUNCH projects. Students felt that learning activities that involved building NASA hardware was important because of the relevance and the sense of accomplishment. This outcome is aligned with prior research conducted by Kember and associates (2008), which found that college undergraduates indicated that establishing relevance of concepts or skills taught was the most important factor for motivating student learning. Their research concluded that, “If teachers wish to motivate their students’ learning, they need to find ways to show the relevance of topics included in their courses” (Kember et al., 2008, p.255).

The students interviewed in this study expressed that classroom learning experiences played an important role in motivating students to pursue STEM courses and careers. Students appreciated the hands-on, challenging nature of HUNCH learning experiences, while working with peers and NASA mentors when engaged in fabricating hardware for NASA. Students indicated that their learning experiences in their STEM HUNCH classes significantly influenced attitudes toward enrolling in other STEM courses.

Research Question 4: Do Students Who Have Fewer Than Two Semesters in HUNCH Perceive STEM Courses and Careers Differently Than Students Who Have Participated in Three or More Semesters in HUNCH?

The potential to have a positive influence on student interest in STEM courses and careers is an important consideration when NASA develops secondary school

programs. With this in mind, this research study sought to determine the influence of the HUNCH program on student motivation to pursue STEM courses and careers. Results from this study found that on almost all of the SIMSQ questions, “experienced in HUNCH” students expressed more positive perceptions of STEM courses than students who were “new to HUNCH” coursework. Because of the complex interaction of factors that influence student motivation to learning, the HUNCH program alone cannot be assumed to be the only reason for the more positive student perceptions of the experienced HUNCH students. However, the results of this research do suggest that instructional activities used in HUNCH coursework incorporate many of the factors that prior research has identified as factors that are important for motivating students toward optimal levels of learning. This outcome suggests that the more experience students have with the HUNCH program the more likely they are to enroll in additional STEM coursework and pursue STEM careers.

A comparison of more experienced HUNCH students to less experienced HUNCH students suggests that students with more HUNCH experience were less bored and more interested in science. These results are in sharp contrast to research by Osborne et al. (2003) and Reis (2004), which found that students’ interest in science decreases when they take more science courses. Furthermore, experienced in HUNCH students felt more successful in STEM related coursework; suggesting that the more experience a student has with STEM HUNCH related coursework, the more likely they are to enroll in additional STEM courses and pursue STEM careers. This finding contradicts some of the prior research on the influence of additional science coursework on students’ interest in

science and course-taking behavior, and suggests that the HUNCH program offers a unique learning experience that has positive influences on student engagement and interest in science and other STEM related areas.

### Implications for Educators

Writers such as Friedman (2005) advocate for the need of today's students to be problem solvers, who can collaborate effectively with others and brainstorm new ideas. Although this research suggests that the HUNCH curriculum provides students with these skills, there are other curricula that have been implemented that provide similar outcomes. The National Science Education Standards (1996) and the three general principles laid out by the Committee on K-12 Engineering (2009) have developed standards and principles that foster inquiry-based learning around challenging content and authentic problem-solving to motivate student learning in STEM areas. These instructional practices are not only intended to increase student interest in STEM coursework but also in STEM careers.

The National Science Education Standards are designed to promote science literacy for all students. These standards define science literacy as an understanding of the usefulness of science and the application of the scientific way of thinking in everyday life (National Research Council, 1996). The second National Science Education Standard focuses on "Science as Inquiry" and is aligned with the instructional approaches such as those used by the HUNCH program for instruction in STEM concepts. This standard includes learning scientific reasoning and creative problem solving skills as a

way to engage students in understanding scientific concepts (National Research Council, 1996).

The Committee on K-12 Engineering defined three principles to guide schools in setting up engineering curricula. These three principles involve teaching engineering design, incorporating science, technology, and mathematics into engineering curricula, and promoting creativity thinking, collaboration, communication and problem solving skills into the engineering curricula (Katehi et al., 2009). The Committee on K-12 Engineering adopted the term “habits of the mind” to refer to the activities listed in the last standard involving creative thinking and collaboration skills.

Research conducted by the Committee on K-12 Engineering and funding from the American Recovery and Reinvestment Act of 2009-2010 was instrumental in the creation of the “STEM Academy.” The aim of the STEM Academy is to improve student interest in STEM education and careers (<http://www.stem101.org/programs.asp>). The STEM Academy features a STEM educational approach that involves challenging hands-on activities that involve the habits of the mind that the Committee on K-12 Engineering advocated for in their last principle of engineering education (<http://www.stem101.org/programs.asp>).

While Project Lead the Way and HUNCH are two school-based programs that meet the National Science Education standards and the Committee on K-12 Engineering principles there are other programs supported by federal, state, local, and private organizations whose goals are to foster these same standards and principles. The majority of these programs are designed to provide professional development for teachers in

STEM areas. The National Math and Science Initiative, American Association for the Advancement of Science: Project 2061, Advancing Teaching of Math and Science (ATOMS), and Partnership to Reform Inquiry Science in Montana (PRISM) are examples of programs that have been created to help STEM teachers align their instruction with the National Science Education Standards. Many other programs are similar to those just highlighted are found on either the National High School Alliance or the MSPnet websites (<http://www.hsalliance.org/stem/index.as>) and ([http://hub.mspnet.org/index.cfm/find\\_projects?project\\_name=&is\\_math=true&is\\_science=true&project\\_state=](http://hub.mspnet.org/index.cfm/find_projects?project_name=&is_math=true&is_science=true&project_state=)).

In addition to state and federally funded STEM programs there are private and government agencies that also supporting school districts in the implementation of STEM academies. Texas, for example, has 51 secondary STEM academies that are involved in innovative programs ([http://www.tea.state.tx.us/index2.aspx?id=4470&menu\\_id=814](http://www.tea.state.tx.us/index2.aspx?id=4470&menu_id=814)). The numbers of STEM educational programs are growing so rapidly that it is difficult to keep up with their expansion. If the goal is to include all students in improved STEM education then the standards and principals of the National Science Education Standards (NRC, 1996) and the Committee of K-12 Engineering principles (NAE, 2009) provide important guidelines for the development of classroom practices.

In STEM HUNCH courses, students are taught how to use all available resources including books, the Internet, and other professionals to collect information that can be tested when engaged in problem-solving. Results from this research suggest that students are inspired to learn when involved in challenging, authentic, hands-on projects that

require creative problem-solving skills. The characteristics of the HUNCH program provide evidence that students are involved in the type of science inquiry recommended by the National Science Education Standards and the Committee on K-12 Engineering. It is difficult to predict the problems that future generations will face; however, research shows that problem-solving requires collaboration and creative thinking (Park, 2006). These skills can be taught through school-based programs such as HUNCH. STEM courses provide a perfect environment to foster creativity and problem-solving. One effective method for teaching these skills is for educators to form partnerships with businesses and organizations that can provide STEM classrooms with challenging projects and professional expertise that support problem-solving activities, requiring divergent thought, collaboration, and persistence.

Students participating in this research study indicated that the environment in which they learn is an essential ingredient in motivating them. This finding concurs with the thinking of situational theorists such as Lave and Wenger (1991) and more recently the work of Park (2006), who proposes that learning occurs best in contextual environments. Their views suggest that partnerships between schools and businesses can play an essential role in promoting STEM education and career interests. If students learn best when they are engaged in authentic activities then forming partnerships with STEM professionals can provide students with authentic projects. This study further suggests that current instructional paradigms in the STEM content areas may benefit by incorporating partnerships with government agencies, businesses, or other research and development oriented organizations that are willing to mentor and provide authentic,

challenging, hands-on projects for STEM classrooms. However, with No Child Left Behind, and the use of test scores to assess student learning, many teachers and schools are constrained by curricula that do not allow for the time required for authentic learning projects.

It is vital for this nation's future that we continue to lead the world toward innovative technological partnerships with other nations. The importance of increasing the quantity, quality, and diversity of students entering STEM careers is essential. This research has provided insights of relevance to educators about critical aspects of instructional practices used in the HUNCH program that promote student interest in STEM coursework and careers.

#### Recommendations for Further Research

Further research needs to be conducted related to the influence of using hands-on, challenging projects as an instructional strategy to improve student learning and interest in the more traditional STEM related courses. Prior studies have investigated the use of hands-on learning activities related to laboratory work in science classes, computers in technology classes, projects in engineering classes, and manipulatives in mathematics classes (Athanasou & Petoumenos, 1994; Benware & Deci, 1984; Cobern et al., 2010). However, the hands-on, authentic learning activities characterizing STEM HUNCH courses were problem-based and presented in real-world contexts rather than artificial, laboratory settings. Students often said that the nature of the hands-on work in STEM HUNCH classes was different than that in other STEM courses in that they were required

to solve problems that naturally occurred when fabricating hardware. These efforts involved real challenges that required creative problem-solving rather than teacher directed step-by-step instructions. Future research should explore how project-based learning activities can be meaningfully incorporated into STEM related coursework; such as science, mathematics, physics, and chemistry.

Future research investigating the use of project-based authentic learning activities used in programs like HUNCH also should include students with parents who work in more diverse occupations. This research only included STEM HUNCH students, who for the most part, lived in communities where an abnormally high number of residents' occupations were in professional STEM fields. Future research should include other communities that do not have such a high concentration of industries that employ a large number of STEM professionals. Studying students with parents that work in a wide variety of occupations may help to improve the external validity of the research outcomes of this study. Results from future research on how innovative school-based programs can reach out to communities not surrounded by technology industries should be examined in an effort to increase the quantity and diversity of a future STEM workforce.

Another research strand that should be examined further is the influence of innovative school-based programs on attracting more diversity along the lines of gender, ethnicity, or social economic status. An important goal of NASA is to increase the diversity of students going into STEM areas. In order to do this, innovative school-based programs need to understand the best classroom practices that will help to increase this diversity. Further research needs to be investigated into the gender imbalance found



among HUNCH students. Among the 169 HUNCH participants only 27 were female. Research focused on the reasons why females are increasingly interested in STEM areas of science and mathematics, but are not pursuing areas such as engineering and technology would contribute to educational practices that foster gender diversity.

This study indicated that family and friends had an influence on students' perceptions of STEM careers. With this knowledge future research on the importance of role models, and particularly female role models, for student motivation to study and pursue STEM areas should be examined. However, future research should investigate the relationship between students' interactions with STEM professionals and their interest in STEM courses and careers. Furthermore, the influence of STEM professionals would be particularly important to research with regard to minority and female students.

One more important issue that this research presented is the need for student self-confidence in mathematics and science as a prerequisite for students to engage in more advanced STEM coursework. This study found that HUNCH students in general had a good self-concept of their abilities in mathematics and science. This was an important factor in motivating them to pursue STEM coursework and careers. The question arises how to engage students in STEM courses who do not have the initial confidence in their mathematics and science abilities.

In addition to investigating instructional strategies used in the HUNCH program, further research should be conducted to determine how STEM professionals, who partner with school districts, influence student interest to pursue STEM coursework and careers. The concept of situated learning emerged as an important motivating environment in

influencing students to enroll in STEM HUNCH courses. Situated learning was well researched by learning theorists such as Lave and Wenger in the early 1990s when studying the relationship between apprenticeships and social development (Rogoff, 1990). However, current research needs to be done in the area of identifying the types of situated learning environments that are most effective for promoting student learning of important concepts and skills related to the STEM content areas.

Finally, while many innovative school-based programs have been well documented because sponsors require this information, there is still a need for future research efforts. In-depth research should investigate not only the instructional activities but also student perceptions of other K-12 STEM curricula in efforts to determine their influence on student interest in STEM courses and careers. For example, research similar to this study could be conducted with national STEM curricula such as Project Lead the Way and Physics First.

### Conclusion

This research identifies ten classroom practices that were found to have positive influences on HUNCH student's interest in STEM courses and STEM careers. The instructional approaches found by this study to motivate student interest in STEM courses and careers were:

1. Hands-on projects that involve authentic tasks
2. Enjoyment of STEM HUNCH classes, where “fun” is not defined traditionally
3. Positive self-concept of ability in STEM areas

4. Lack of anxiety in STEM classes, where mistakes are viewed as learning opportunities
5. Challenging work that involves mentoring from peers and professionals
6. Student-centered learning where the teacher is seen as a facilitator and the students are allowed to work collaboratively
7. Relevance of STEM HUNCH projects that are valued by NASA and allow students to understand the applications of their STEM conceptual learning
8. Career interest in STEM areas, where students are motivated to learn all that they can, because their learning is necessary for their educational and career goals
9. Influence of contact with family and friends that are involved in STEM areas
10. Exposure to STEM classes that are partnered with STEM professional organizations such as NASA

The first eight practices listed are well-supported by prior research that has investigated factors that influence motivation and learning. However, the last two instructional approaches are classroom practices that are unique findings that emerged from this research study. While there already exist various innovative school-based programs that incorporate general principles and specific practices similar to those identified in HUNCH, it is hoped that the results of this research will guide decision making leading to the redesign of existing STEM programs for high school students, as well as the creation of new programs.

REFERENCES CITED

- About the school. (n.d.). Retrieved from <http://epcot.jc.schoolinsites.com/?PageName='AboutTheSchool'>.
- A World in Motion web page <http://www.awim.org/about/facts/>. Retrieved from <http://www.awim.org/about/facts/>.
- Alberts, B. (2009). Redefining Science Education. *Science*, 323,437. Retrieved from [http://ucce.ucdavis.edu/files/workgroups/6798/Alberts\\_Editorial\\_on\\_Science\\_Knowledge\\_and\\_Assessment.pdf](http://ucce.ucdavis.edu/files/workgroups/6798/Alberts_Editorial_on_Science_Knowledge_and_Assessment.pdf).
- Alexander, P.A., & Winnie, P.H. (2006). *Handbook of Educational Psychology (2<sup>nd</sup> ed.)*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Amabile, T.M., & Hennessey, B.A. (1992). The motivation of creativity in children. In A.K. Boggiano, & Pittman, T.S. (Eds.). *Achievement and Motivation A Social-Developmental Perspective* (pp. 54-72). New York, NY: Cambridge University Press.
- Ames, R.E., & Ames, C. (1984). *Research on Motivation in Education Volume 1*. San Diego, CA: Academic Press, Inc.
- Association for Career and Technical Education Issue Brief. (2009). *CTE's Role in Science, Technology, Engineering & Math*. Retrieved from [www.acteonline.org](http://www.acteonline.org).
- Athanasou, J.A., & Cooksey, R.A. (2001). Judgement of factors influencing interest: An Australian study. *Journal of Vocational Education Research* 26(1).
- Athanasou, J.A., & Petoumenos K. (1994). Which components of instruction influence student interest. *Australian Journal of Teacher Education*, 23(2).
- Atkinson, J. W. (1957). Motivational determinants of risk-taking behavior. *Psychological Review*, 64(6p1), 359-372. Retrieved from [http://csaweb110v.csa.com.proxybz.lib.montana.edu/ids70/view\\_record.php?id=1&rec](http://csaweb110v.csa.com.proxybz.lib.montana.edu/ids70/view_record.php?id=1&rec).
- Atkinson, J.W., & Feather, N.T. (1966). *A Theory of Achievement Motivation*. New York, NY: John Wiley & Sons, Inc.
- Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist*, 44(9), 1175-1184.
- Bandura, A. (1994). Self-Efficacy. *Encyclopedia of Human Behavior*, 4, 71-81. Retrieved from <http://www.des.emory.edu/mfp/BanEncy.html>.
- Bandura, A. (1997). *Self-Efficacy the Exercise of Control*. New York, NY: W.H. Freeman and Company.

- Bangert, A. (2008). *Educational Statistics II EDCI 502*, Montana State University. Bozeman, MT.
- Barmby, P., Kind, P.M., & Jones, K. (2008). Examining changing attitudes in secondary school science. *International Journal of Science Education*, 30(8), 1075-1093.
- Benware, C., & Deci, E.D. (1984) Quality of learning with an active versus passive motivational set. *American Educational Research Journal*, 21(4), 755-757.
- Bolles, R.C., (1975). *Theory of Motivation*. New York, NY: Harper & Row, Publishers.
- Bottoms, G., & Uhn, J., (2007, September). Project Lead The Way works: A new type of career and technical program. Southern Regional Education Board Research Brief Retrieved from [www.sreb.org](http://www.sreb.org).
- Bouffard-Bouchard, T., Parent, S., & Larivee, S. (1991). Influence of self-efficacy on self-regulation and performance among Junior and Senior High-School age students. *International Journal of Behavioral Development*, 14(2), 153-164. Retrieved from <http://jbd.sagepub.com/cgi/content/abstract/14/2/153>.
- Brown, J.S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher* 18(32), 32-42.
- Burns, M. (1998). *Math: Facing an American Phobia*. Sausalito, CA: Math Solutions Publications.
- Cech, S. J. (2007). Engineering a blueprint for success. *Education Week*, 27(5), 26-29.
- Chavanne, B.H. (2008). Sea change. *Aviation Week & Space Technology*, 169(7), 81-82.
- Chinn, S. (2008). Mathematics anxiety in secondary students in England. *DYSLEXIA* 15, 61-68. Retrieved from [www.interscience.wiley.com](http://www.interscience.wiley.com).
- Cobern, W. W., Schuster, D. G., & Adams, B. (2010). Experimental comparison of inquiry and direct instruction in science. *Society for Research on Educational Effectiveness Abstract Template*. Retrieved from <http://www.informaworld.com.proxybz.lib.montana.edu/smpp/content~db=all?content=10.1080/02635140903513599>.
- Collins, A., Brown, J.S., & Holum, A. (1991). Cognitive apprenticeship: Making thinking visible. *American Educator*, Winter Issue. Retrieved from [www.citeseerx.ist.psu.edu](http://www.citeseerx.ist.psu.edu).
- Collins, A., & Halverson, R. (2009). *Rethinking Education in the Age of Technology*. New York, NY: Teachers College Press.

- Corbett, C., Hill, C., & St. Rose, A. (2008). *Where the Girls Are: The Facts About Gender Equity in Education*. AAUW Educational Foundation. Washington, DC. Retrieved from <http://www.aauw.org/research/upload/whereGirlsAre.pdf>.
- Corbin, J., & Strauss, A. (2008). *Basics of Qualitative Research 3e*. Thousand Oaks, CA: Sage Publications, Inc.
- Creswell, J.W. (2007). *Research design: Qualitative, Quantitative, and mixed methods approaches*. Thousand Oaks, CA: Sage.
- Creswell, J.W. (2002). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Upper Saddle River, NJ: Merrill Prentice Hall.
- Csikszentmihalyi, M. (1990). *Flow The Psychology of Optimal Experience*. New York, NY: Harper & Row, Publishers.
- Darling-Hammond, L. (2010). *The Flat World and Education: How America's Commitment to Equity Will Determine Our Future*. New York, NY: Teachers College Press.
- Davis, C.A. (2004). *CCHS Students Build Success NASA Thinks Out-Side the Box to Create Low-Cost Solution*. NASA Communicator-Spring February 22, 2004.
- Deci, E.D., & Ryan, R.M. (1992). The initiation and regulation of intrinsically motivated learning and achievement. In A.K. Boggiano, & T.S. Pittman (Eds.), *Achievement and Motivation A Social-Developmental Perspective* (pp. 9-36). New York, NY: Cambridge University Press.
- Demographics. (2009-2010). Retrieved from [http://schools.cfid.net/cywoods/profile\\_cywo.htm#demo](http://schools.cfid.net/cywoods/profile_cywo.htm#demo).
- Demski, J. (2009). STEM picking up speed. *T.H.E. Journal Magazine*, 36(1), 22-26. Retrieved from [www.thejournal.com](http://www.thejournal.com).
- Dewey, J. (1910). *How We Think [1910]*. (2009). Daners, MA: General Books LLC.
- Dewey, J.(1938). *Experience and Education*. New York, NY: Touchstone.
- Driscoll, M.P. (2000). *Psychology of Learning for Instruction*. Boston, MA: Allyn and Bacon.
- Educational Commission of States. (2009). *Project Lead The Way Receives National Recognition from Educational Commission of States*. Retrieved from <http://www.reuters.com/article/pressRelease/idUS71411+18-Jun-2009+PRN20090618>.

Find project. (n.d.). Retrieved from [http://hub.mspnet.org/index.cfm/find\\_projects?project\\_name=&is\\_math=true&is\\_science=true&project\\_state=](http://hub.mspnet.org/index.cfm/find_projects?project_name=&is_math=true&is_science=true&project_state=)

Friedman, T.L. (2005). *The World is Flat*. New York, NY: Farrar, Straus and Giroux.

Gliner, J.A., & Morgan, G.A. (2000). *Research Methods in Applied Settings*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Goodman, R. (2006). A new high school science program and its effect on student achievement in mathematics and science. (Doctoral Dissertation, Rutgers University at New Brunswick, New Jersey). Retrieved from <http://proquest.umi.com.proxybz.lib.montana.edu/pqdweb?index=0&did=1296084851&SearchMode=2&sid=1&Fmt=2&VInst=PROD&VType=PQD&RQT=309&VName=PQD&TS=1301092547&clientId=19144>.

Gravetter, F.J., & Wallnau, L.B. (2007). *Statistics for the Behavioral Sciences* (7<sup>th</sup> ed.). Belmont, CA: Thomson \* Wadsworth.

Hake, R.(1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66, 64-74.

Hale, S.L. (2009). HUNCH Project Kick-Off 2009-2010 Announcement.

Hale, S.L. (2006). HUNCH Program-Draft. Announcement.

Hardre, P.L., Davis, K.A., & Sullivan, D.W. (2008). Measuring teacher perceptions of the “how” and “why” of student motivation. *Educational Research and Evaluation*, 14(2), 155-179.

Hassan, G. (2008). Attitudes toward science among Australian tertiary and secondary school students. *Research in Science & Technological Education*, 26(2), 129-147.

Heyl, A. (2008). Fostering engagement for students from low-socioeconomics status backgrounds using project-based mathematics. (Doctoral Dissertation, Dominican University of California). Retrieved from [http://csaweb105v.csa.com.proxybz.lib.montana.edu/ids70/view\\_record.php?id=7&recnum=1&log=from\\_res&SID=vtekkcv63cpilu9legoj4tt7g0&mark\\_id=search%3A7%3A30%2C0%2C3](http://csaweb105v.csa.com.proxybz.lib.montana.edu/ids70/view_record.php?id=7&recnum=1&log=from_res&SID=vtekkcv63cpilu9legoj4tt7g0&mark_id=search%3A7%3A30%2C0%2C3).

Hickam, H. (1998). *October Sky*. New York, NY: Dell Publishing.

Hickey, D.T. (1997). Motivation and contemporary socio-constructivist instructional perspectives. *Educational Psychologist*, 32(3), 175-193.



Hidi, S. (2000). An interested researcher's perspective: The effects of extrinsic and intrinsic factors on motivation. In C. Sansone, & J.M. Harackiewicz (Eds.), *Intrinsic and Extrinsic Motivation The Search for Optimal Motivation and Performance* (pp.309-339). New York, NY: Academic Press.

Hudy, G.T. (2006). An analysis of motivational factors related to academic success and persistence for university students. (Doctoral Dissertation, Indiana University of Pennsylvania). Retrieved from <http://proquest.umi.com.proxybz.lib.montana.edu/pqdweb?index=1&did=1251863381&SearchMode=1&sid=5&Fmt=2&VInst=PROD&VType=PQD&RQT=309&VName=PQD&TS=1301092809&clientId=19144>.

Huitt, W. (2001). Motivation to learn: An overview. *Education Psychology Interactive*. Retrieved from <http://chiron.valdosta.edu/whuitt/col/motivation/motivate.html>.

Hulleman, C.S., & Harackiewicz, J.M. (2009). Promoting interest and performance in high school science classes. *Science*. Retrieved from [www.sciencemag.org](http://www.sciencemag.org).

Huntsville Center for Tech. (2008-2009). Retrieved from <http://www.greatschools.org/cgi-bin/al/other/755#students>.

Huntsville City Schools Annual Report. (2009-2010). Retrieved from <http://www.hsv.k12.al.us/HCSAnnualReport09-10.pdf>.

Jain, S., & Dowson, M. (2009). Mathematics anxiety as a function of multidimensional self-regulation and self-efficacy. *Contemporary Educational Psychology* 34, 240-249. Retrieved from [www.elsevier.com/locate/cedpsych](http://www.elsevier.com/locate/cedpsych).

Johnson, E.W, (2004). *Study Guide for Woolfolk Educational Psychology (9<sup>th</sup> ed.)*. Boston, MA: Pearson Education, Inc.

Johnson, L. (2007, April 30). *Students Build Hardware for NASA*. Audio broadcast. Retrieved from [http://www.kuhf.org/site/News2?page=NewsArticle&id=20170&news\\_iv\\_ctrl=19](http://www.kuhf.org/site/News2?page=NewsArticle&id=20170&news_iv_ctrl=19).

Jukes, I. (2003). *The New Digital Landscape*. The InfoSavvy Group.

Katehi, L., Pearson, G., & Feder, M. (Eds.) (2009). *Engineering in K-12 Education Understanding the Status and Improving the Prospects*. Washington, DC: The National Academies Press.

Keller, J. (2000). *How to Integrate Learner Motivation Planning Into Lesson Planning: The ARCS Model Approach*. Paper presented at VII Semanario, Santiago, Cuba.

- Kember, D., Ho, A., & Hong, C. (2008). The importance of establishing relevance in motivating student learning. *Active Learning in Higher Education*. Retrieved from <http://alh.sagepub.com/cgi/content/abstract/9/3/249>.
- Kind, P., Jones, K., & Barmby, P. (2007). Developing attitudes towards science measures. *International Journal of Science Education*, 29(7), 871-893.
- Kinzie, M.P., Sullivan, H.J., & Berdel, R. L. (1988). Learner control and achievement in science computer-assisted instruction. *Journal of Educational Psychology*, 80(3), 299-303.
- Kohn, A. (2005). *Unconditional Parenting*. New York, NY: Simon & Schuster, Inc.
- Kolesnik, W. B. (1975). *Humanism and /or Behaviorism in Education*. Boston, MA: Allyn and Bacon, Inc.
- Lau, S. (2002). Cognitive abilities and motivational processes in high school students' science achievement and engagement. (Doctoral Dissertation, Stanford University at Menlo Park, CA). Retrieved from [http://csaweb105v.csa.com.proxybz.lib.montana.edu/ids70/view\\_record.php?id=7&recnum=1&log=from\\_res&SID=vtekkcv63cpilu9legoj4tt7g0&mark\\_id=search%3A7%3A30%2C0%2C3](http://csaweb105v.csa.com.proxybz.lib.montana.edu/ids70/view_record.php?id=7&recnum=1&log=from_res&SID=vtekkcv63cpilu9legoj4tt7g0&mark_id=search%3A7%3A30%2C0%2C3).
- Lave, J., & Wenger, E. (1991). *Situated Learning: Legitimate Peripheral Participation*. Cambridge, United Kingdom: Cambridge University Press.
- Lawrenz, F. (2006). Summary and critique of selected evaluations of NASA educational programs. Washington, DC: Board on Science Education. Retrieved from <http://www.informalscience.org/research/show/3688>.
- Lee, J. (2007). Universals and specifics of math self-concept, math self-efficacy, and math anxiety across 41 PISA 2003 participating countries. *Learning and Individual Differences* 19, 355-365. Retrieved from [www.elsevier.com/locate/lindif](http://www.elsevier.com/locate/lindif).
- Leech, N.L., Barrett, K.C., & Morgan, G.A. (2008). *SPSS for Intermediate Statistics Use and Interpretation (3<sup>rd</sup> ed.)*. New York, NY: Lawrence Erlbaum Associates.
- Lincoln, Y.S., & Guba, E.G. (1985). *Naturalistic Inquiry*. Newbury Park, CA: Sage.
- Maslow, A.H. (1943). A theory of human motivation. *Psychological Review* 50(4), 370-396.

Massachusetts Institute of Technology (2009) "Survey: Majority of U.S. Teens Feel Prepared for Careers in Science, Technology, Engineering and Mathematics, Yet Many Lack Mentors," Retrieved from <http://web.mit.edu/newsoffice/2009/print/lemelson-teens-0107-print.html>.

Mayan, M.J. (2009). *Essentials of Qualitative Inquiry*. Walnut Creek, CA: Left Coast Press, Inc.

Mission statement. (n.d.). Retrieved from <http://www2.ccisd.net/AboutCCISD.aspx>.

Murphy, P. K., & Alexander, P.A. (2000). A Motivated Exploration of Motivation Terminology. *Contemporary Educational Psychology* 25, 3-53 Retrieved from <http://www.idealibrary.com>.

NASA's planned investments in education. (2006). Retrieved from <http://education.nasa.gov/about/factsheet/index.html>.

National Academy of Engineering. (2009). The status and nature of engineering education in the United States. *The Bridge* 39(3), 5-10. Retrieved from <http://www.nae.edu/File.aspx?id=16147>.

National Center for Earth and Space Science Education web page <http://ncesse.org>. Retrieved from <http://ncesse.org>.

National Science Board, *Science and Engineering Indicators 2008* (Arlington, VA National Science Foundation, 2008) Retrieved from <http://www.nsf.gov/statistics/seind08/urlsend.ctm>.

National Science Board, *Science and Engineering Indicators 2010 Release* (Arlington, VA National Science Foundation, 2010) Retrieved from [http://www.aaas.org/spp/rd/news/20100115sei\\_release.pdf](http://www.aaas.org/spp/rd/news/20100115sei_release.pdf).

National Research Council. (1996). National Science Education Standards. Washington, DC: National Academy Press. Retrieved from [http://www.nap.edu/openbook.php?record\\_id=4962](http://www.nap.edu/openbook.php?record_id=4962).

Nguyrn, D.V., & Hale, K. (2005). *Student-Built Space Station on Earth*. Retrieved from [http://www.nasa.gov/audience/foreducators/9-12/features/F\\_Students\\_Learn\\_About\\_Space\\_Station\\_prt.htm](http://www.nasa.gov/audience/foreducators/9-12/features/F_Students_Learn_About_Space_Station_prt.htm).

Organization for economic co-operation and development, "PISA 2006: Science Competencies for Tomorrow's World Executive Summary" Retrieved from [http://www.oecd.org/document/2/0,3343,en\\_32252351\\_32236191\\_39718850\\_1\\_1\\_1\\_1,0.html](http://www.oecd.org/document/2/0,3343,en_32252351_32236191_39718850_1_1_1_1,0.html).

- Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, 25(9), 1049-1079.
- Palincsar, A.S. (1989). Commentary: Less charted waters. *Edicatopma; Researcher*, 18(5), 5-7.
- Park, D. (2006). Curriculum reform movement in the US-Science Education. Paper Presented at the 1<sup>st</sup> Pacific Rim Conference on Education, Hokkaido University of Education, Hokkaido, Japan.
- Patton, M.Q. (2002). *Qualitative Research and Evaluation Methods (3<sup>rd</sup> ed.)*. Thousand Oaks: Sage Publishing.
- Perkins, D. N. (2009). *Making Learning Whole: How Seven Principles of Teaching can Transform Education*. San Francisco, CA: Jossey-Bass.
- Piaget, J. (1971). *Biology and Knowledge: An Essay on the Relations between Organic Regulations and Cognitive Processes*. Translated by Beatrix Walsh. Chicago, IL: The University of Chicago Press.
- Pintrich, P.R., & Schunk, D. H. (2002). *Motivation in Education (2<sup>nd</sup> ed.)*. Upper Saddle River, NJ: Pearson Education, Inc.
- Project Lead The Way official web page <http://www.pltw.org>. Retrieved from <http://www.pltw.org>.
- Quihuis, G. (2001). Understanding the factors that influence high science achievers' academic choices and intent to pursue or opt out of the hard sciences. (Doctoral Dissertation, Stanford University). Retrieved from <http://proquest.umi.com.proxybz.lib.montana.edu/pqdlink?Ver=1&Exp=03-23-2016&FMT=7&DID=726360931&RQT=309&attempt=1&cfc=1>.
- Reiss, M.J. (2004). Students' attitudes towards science: A long-term perspective. Retrieved from [www.ioe.ac.uk/schools/mst/staff/ReissM/cJSMTE pub.pdf](http://www.ioe.ac.uk/schools/mst/staff/ReissM/cJSMTE%20pub.pdf).
- Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. New York, NY: Oxford University Press.
- Ryan, R.M., Connell, J.P., & Grolnick, W.S. (1992). When achievement is not intrinsically motivated: A theory of internalization and self-regulation in school. In A.K. Boggiano, & Pittman, T.S. (Eds.), *Achievement and Motivation A Social-Developmental Perspective* (pp.167-188). New York, NY: Cambridge University Press.

Sansone, C., & Harackiewicz, J.M. (2000). Looking beyond rewards: The problem and promise of intrinsic motivation. In C. Sansone, & J.M. Harackiewicz (Eds.), *Intrinsic and Extrinsic Motivation The Search for Optimal Motivation and Performance* (pp.1-9). New York, NY: Academic Press.

Schiefele, U. (1991). Interest, learning, and motivation. *Educational Psychologist* 26(3 & 4), 299-323.

Shay, B. (2005). 2 Students help space program. *Billings Gazette*, May 17, 2005.

Shih, Shu-Shen. (2008). The relation of self-determination and achievement goals to Taiwanese eighth graders' behavioral and emotional engagement in schoolwork. *The Elementary School Journal*, 108(4), 313-334.

Smith, R. (2009). 2009 'HUNCH' Project Under Way Alabama, Tennessee students help NASA develop Ares 1. *Marshall Star*, 49(22), 4.

Statistical Package for Social Sciences Statistics GradPack 17.0 for Windows. (2008). Chicago, IL: 2008 SPSS Inc.

Stipek, D. (2002). *Motivation to learn integrating theory and practice*. Boston, MA: Allyn and Bacon.

Stipek, D., & Seal, K. (2001). *Motivated Minds Raising Children to Love Learning*. New York, NY: Henry Holt and Company.

Student Spaceflight Experiments Program web page <http://ssep.ncesse.org>. Retrieved from <http://ssep.ncesse.org>.

Suzuki, S. (1983). *Nutured by Love*. Smithtown, NY: Exposition Press.

Teppo, M., & Rannikmäe, M. (2004). Relevant science education in the eyes of grade nine students. Paper presented at the XI IOSTE (International Organization for Science and Technology Education) symposium: Science and Technology Education for a Diverse World, Lublin, Poland. Retrieved from <http://www.ils.uio.no/english/rose/network/countries/estonia/est-teppo-ioste2004.pdf>.

The Cambrian Way. (n.d.) Retrieved from <http://www.cambrianacademy.org/aboutus.html>.

Thomas, D.A., Robinson, J.A., Tate, J., & Thumm, T. (2006). *Inspiring the Next Generation: Student Experiments and Educational Activities on the International Space Station, 2000-2006*. Hanover, MD: NASA Center for AeroSpace Information.

- Tobias, S. (1979). Anxiety research in educational psychology. *Journal of Educational Psychology* 71(5), 573-582.
- Vygotsky, L.S. (1997). *Educational Psychology*. Introduction V.V. Davydov. Translated by Robert H. Silverman. Boca Raton, FL: St. Lucie Press. (Originally published in Russian, 1926).
- Vygotsky, L.S. (1986). *Thought and Language*. Translated by Alex Kozulin. Cambridge, MA: The MIT Press.
- Walcerx, D. (2007). Report on the third year of implementation of the true outcomes assessment system for Project Lead the Way. Retrieved from <http://www.pltw.org/pdfs/AnnualReport-2007-Public-Release.pdf>.
- Webster, N. (1975). *Webster's New Twentieth Century Dictionary*. Edited by Jean M. L. Second Edition. New York, NY: William & Collins World Publishing Co., Inc.
- Weiner, B. (1992). *Human Motivation Metaphors, Theories, and Research*. Newbury Park: Sage Publications.
- Weiner, B. (1986). *An Attribution Theory of Motivation and Emotion*. New York, NY: Springer-Verlag.
- Weiss, I.R., Pasley, J.D., Smith, P.S., Banilower, E.R., & Heck, D.J. (2003). Highlights report looking inside the classroom: A study of k-12 mathematics and science education in the United States. Retrieved from <http://www.horizon-research.com/insidetheclassroom/reports/highlights/>.
- Wineburg, S.S. (1989). Commentary: Remembrance of theories past. *Educational Researcher*, 18(7), 7-12.
- Winters, J. (2008). Kelly Link with Schools for Engineers. *Mechanical Engineering*, 130(7), 10.
- Wlodkowski, R.J. (2008). *Enhancing Adult Motivation to Learn A comprehensive Guide for Teaching All Adults*. San Francisco, CA: John Wiley & Sons, Inc..
- Woolfolk, A. (2004). *Educational Psychology (9<sup>th</sup> ed.)*. Boston, MA: Pearson Education, Inc..
- Zuckerman, M., Bernieri, F., Koestner, R., & Rosenthal, R. (1989). To predict some of the people some of the time: In search of moderators. *Journal of Personality and Social Psychology* 57(2), 279-293.

APPENDICES

APPENDIX A

NASA'S EDUCATIONAL GOALS

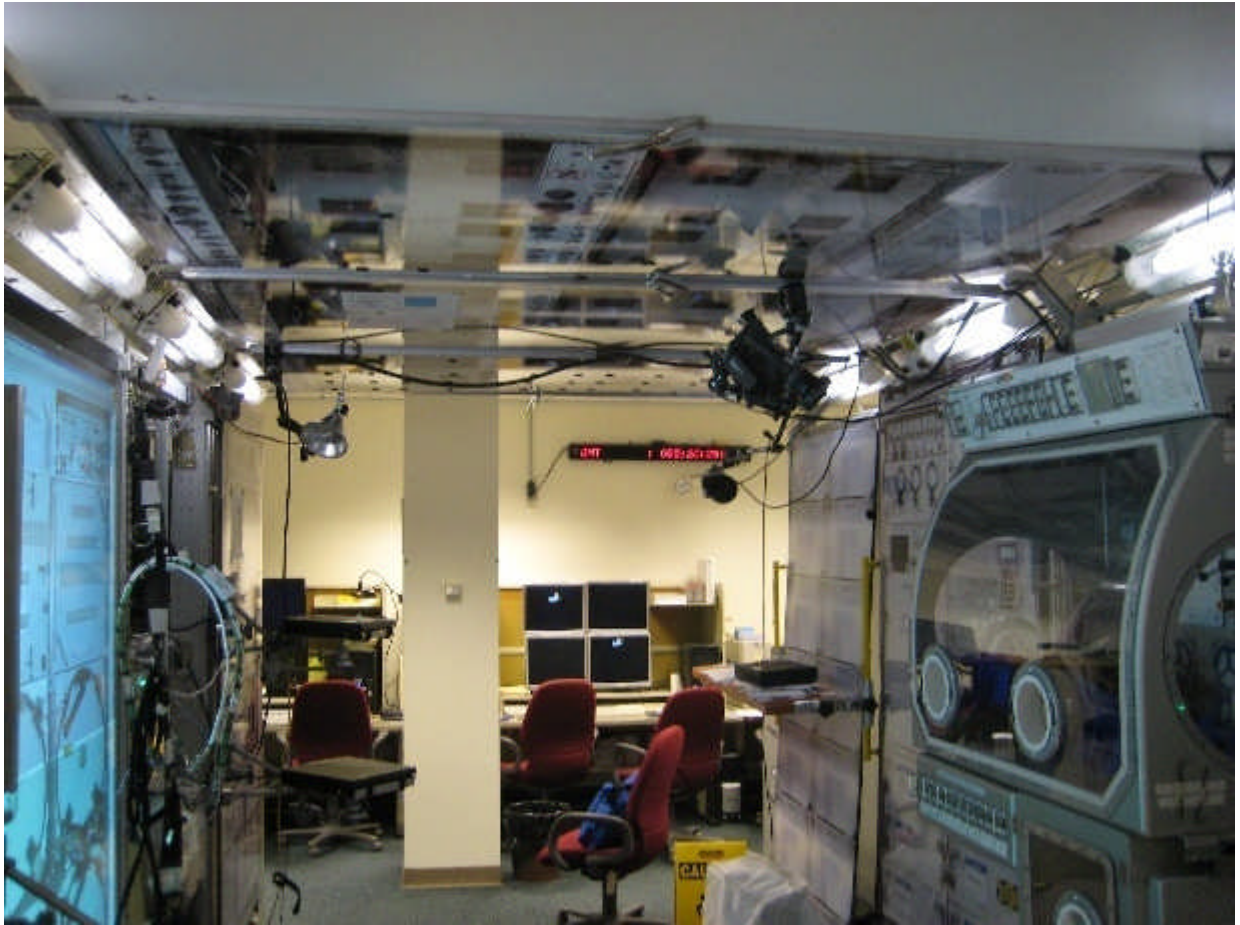


### NASA's Educational Goals

- 1) Strengthen NASA and the nation's future workforce -- NASA will identify and develop the critical skills and capabilities needed to insure achievement of the Vision for Space Exploration. To help meet this demand, NASA will continue contributing to the development of the nation's science, technology, engineering and mathematics, or STEM, workforce of the future through a diverse portfolio of education initiatives that target America's students of all levels, especially those in traditionally underserved and underrepresented communities.
- 2) Attract and retain students in STEM disciplines -- To compete effectively for the minds, imaginations, and career ambitions of America's young people, NASA will focus on engaging and retaining students in STEM education programs to encourage their pursuit of educational disciplines critical to NASA's future engineering, scientific and technical missions.
- 3) Attract and retain students in STEM disciplines -- To compete effectively for the minds, imaginations, and career ambitions of America's young people, NASA will focus on engaging and retaining students in STEM education programs to encourage their pursuit of educational disciplines critical to NASA's future engineering, scientific and technical missions  
[\(<http://education.nasa.gov/about/factsheet/index.html>\)](http://education.nasa.gov/about/factsheet/index.html).

APPENDIX B

NASA PHOTOGRAPHS OF HUNCH STUDENT PROJECTS



Marshall Space Flight Center Training Laboratory made completely by HUNCH students



ISS Single Stowage Locker made by HUNCH students



Table that is going to the ISS made by HUNCH students

APPENDIX C

STRUCTURE OF THE HUNCH PROGRAM

**HUNCH Program**

<b>Institution</b>	National Aeronautics and Space Administration Johnson Space Center Mail Code OZ 2101 NASA Parkway Houston, TX 77058 Tel: (281) 483-6302 Fax: (281) 244-8292 E-mail: Stacy.L.Hale@NASA.GOV Web site: www.nasahunch.com
<b>Leaders</b>	Stacy Hale, HUNCH Project Manager, Johnson Space Center, Payload Office
<b>Funding</b>	Robert Zeek, Marshall Space Flight Center, Payload Projects Office
<b>Grade Level</b>	Funding from NASA Payload Projects Office and residual assets
<b>Web Site</b>	7-12 <sup>th</sup> grades
<b>Espoused Mission</b>	<a href="http://www.nasahunch.com">www.nasahunch.com</a>
<b>Espoused Mission</b>	“To inspire the next generation of explorers” (HUNCH: The birth, Phase One and where do we go from here 2004)
<b>Fabrication of Hardware</b>	The curriculum features the following fabrication and documentation of training hardware for NASA astronauts: <ul style="list-style-type: none"> <li>Single Stowage Lockers</li> <li>Generic Luminaire Assemblies</li> <li>Caution and Warning Panels</li> <li>Utility Outlet Panels</li> <li>Harness Making</li> <li>Trailer Construction</li> <li>Virtual Training Rack</li> <li>Electric Circuitry</li> <li>Stand-off Interface Panels</li> <li>3-D Design of Ares Engine Parts</li> <li>Wardroom Table</li> <li>Refrigerator/Oven</li> <li>Relay Switches</li> <li>Rack Power Smoke Indicator Units</li> <li>Glove Box</li> <li>Cargo Transfer Bags</li> <li>Tool Drawers</li> <li>Internal Vehicular Activity Handrails</li> <li>Treadmill Vibration Isolation System Rope Assembly Units</li> <li>Gas Analyzer Training Units</li> <li>Lab Training Center Control Cabinet</li> <li>Design and Model Hardware for the Ares 1 Upper Stage and J-</li> </ul>

	2-X engine ( <a href="http://www.nasa.gov">www.nasa.gov</a> )
<b>Knowledge/ Skills</b>	<p>Every piece of hardware fabricated involves specific skills that include but are not limited to the following:</p> <ul style="list-style-type: none"> <li>Teamwork</li> <li>Scale and Full Size Parts</li> <li>Soldering to Certified Standards</li> <li>Crimping to NASA Certified Standards</li> <li>Welding TIG/MIG NASA Certified Program</li> <li>Plasma Cutting</li> <li>CNC Machining, Programming, and Fabrication</li> <li>Manual Mills, Lathes, and Grinders</li> <li>Operation of 3-D Printer</li> <li>2d/3d AutoCAD</li> <li>Rapid Prototyping</li> <li>Computer Programming: C+, Visual Basic, I/O Address</li> <li>Graphic Design</li> <li>Wiring: Cables, Connectors, and Pins</li> <li>Prep, Prime, Paint, Powder Coating, and Etching</li> <li>Sanding</li> <li>Quality Control Testing</li> <li>Shrink Wrapping</li> <li>Harness Making</li> <li>Schematic Reading</li> <li>Journaling</li> <li>Sewing</li> </ul>
<b>Pedagogical Elements</b>	<p>The following pedagogical elements can be found in the fabrication and documentation of each project:</p> <ul style="list-style-type: none"> <li>Authentic engineering design tasks</li> <li>Authentic problem-solving to meet real world NASA requirements</li> <li>Challenging and interesting to students in high school</li> <li>Precision and quality control to meet NASA's specifications</li> <li>Application of science and mathematics skills</li> <li>Creativity and logical thinking to solve encountered problems</li> <li>Student use of high-tech equipment</li> <li>Design and redesign iterations</li> <li>The teachers' role is a facilitator, who provides scaffolding when needed</li> <li>Working in teams and/or with partners</li> <li>Input from several vocational/technical courses</li> </ul>
<b>Maturity</b>	<p>The HUNCH program started in the 2003-2004 school year with three schools. It has expanded each year since then. At the beginning of the 2009-2010 school year, there were 29 schools located in Texas, Alabama, Montana, Tennessee, Colorado, Wyoming, South Dakota, and</p>

Florida. There are over 600 students participating in HUNCH activities each year (Bob Zeek, 2005). The HUNCH program's activities have expanded from training hardware, to certified flight hardware, to engineering designs, and student flight experiments on the ISS.

**Phase 1:** Stacy Hale and Bob Zeek went looking for high schools that had the capabilities to perform metal fabrication to build ISS Single Stowage Lockers. Hale found Clear Creek High School and Zeek found Huntsville Center for Technology and Brewer High School. Each school contributed to a different part of the lockers and there were 30 lockers built the first year. At the end of phase 1, NASA realized that schools could build quality hardware at a substantial cost savings for NASA.

**Phase 2:** The HUNCH program added seven more schools in 2004 and students worked on additional tasks including electronics and the development of a Destiny Laboratory trailer utilized for training and visiting schools.

**Phase 3:** The HUNCH program added 12 more schools in 2005 and more training hardware fabrication tasks. The students in Houston began the design, documentation, and fabrication of a dining table for use on the ISS. Students in Alabama began the design and modeling of hardware for the Ares 1 Upper Stage and J-2X engine ([www.nasa.gov](http://www.nasa.gov)).

**Future:** Continue adding NASA facilities to the HUNCH program that will promote HUNCH projects in their areas. Also add a HUNCH National Laboratory project in which students will be tasked with the design, documentation, and fabrication of experiments to fly on the International Space Station.

## Impact

### **To make school work more challenging**

The HUNCH program was piloted in Texas and Alabama, with schools around Johnson Space Center and Marshall Space Flight Center. These schools produced positive results evidenced by the testimony from teachers, students, and parents. For example, one HUNCH student was quoted as saying, "The challenges brought about as you construct your project allow you to push yourself to extremes mentally."

([http://technology.jsc.nasa.gov/hunch\\_story.cfm](http://technology.jsc.nasa.gov/hunch_story.cfm))

Students around Marshall Space Flight Center are really being challenged by teaming with engineers in fabricating prototypes for elements of the Ares 1 and J-2X engine of Ares 1 upper stage of the rocket. To accomplish this task, these students are using cutting edge design modeling tools and techniques while teleconferencing with NASA engineers (Alabama, Tennessee students help NASA develop



Ares 1 by Rick Smith. Marshall STAR. February 19, 2009).

### **To improve dropout rate at schools**

The HUNCH program has an impact on students' desire to go to school. One student wrote, "Before I became involved with the HUNCH project I did not want to come to school" and "This experience has completely changed the way I look at school and the importance it plays in my future." ([http://technology.jsc.nasa.gov/hunch\\_story.cfm](http://technology.jsc.nasa.gov/hunch_story.cfm))

Another student wrote, "I really enjoyed my experience with HUNCH. It gives me something to look forward to each day at school" (Student-Built Space Station on Earth NASA News June 23, 2006. Retrieved 8/15/2009 from [www.nasa.gov](http://www.nasa.gov) ).

Hale designed the program to reach students that NASA normally did not reach. He said, "These are students NASA normally does not have a program for, but now we are creating an interest and a niche in the space industry that suits these children" (February 22, 2004 NASA Communicator).

### **To increase student self-esteem**

The HUNCH program has had a positive impact on student self-esteem. Hale states, "One of the best parts of my job is watching kids uncover self-confidence they never knew they had, simply because they felt like they were doing something relevant and valuable"

([http://technology.jsc.nasa.gov/hunch\\_story.cfm](http://technology.jsc.nasa.gov/hunch_story.cfm))

A student in Alabama stated, "It shows high school students are capable of handling real life projects" (HUNCH program February 17, 2005).

A HUNCH teacher reported that the HUNCH projects stretch his students' minds. He said, "I try to do projects that are complicated so that they can know they can stretch themselves and be successful" (February 22, 2004 NASA communicator).

### **To increase students' sense of pride and accomplishment**

One HUNCH student was so proud of his HUNCH work he said, "I think it is really neat that something that has touched my hands may end up going into space or helping in space. It is almost as good as me going into space" (February 22, 2004 NASA Communicator). Teresa

Vanhooser, acting director of Marshall Space Flight Center said the following about HUNCH students, "They are building the hardware we need to continue our exploration of space. And at the same time, it may inspire these young people to choose careers in science and engineering" (Students build Space Station training lockers by Lori Johnson February 24, 2005, Marshall STAR)

**To promote the attitude that failure is not an option**

When problems arise in building hardware for NASA, students have to find solutions themselves. As one student said, “We have to figure out a way around it (problem)” and his teacher said, “The experience they’re getting from this project they couldn’t get out of a textbook” (Training HUNCH pays off for NASA. Huntsville Times February 14, 2005).

Another HUNCH student summed up the real-world problem-solving requirements when he said, “We’re working with a real problem and when difficulties arise, we can’t just go to our teacher and say, we have a problem. We have to figure out how to fix it” (The Sky is ‘Not’ the Limit for Career/Tech Students. Department of Education State of Alabama July 25, 2005).

**To promote student interest in NASA’s goals and objectives**

Zeek said, “Hopefully, the students involved will become motivated and challenged to continue studies that lead to work supporting NASA’s or TBE’s (Teledyne Brown Engineering) goals and objectives” (High School Students Create Hardware for NASA. Teledyne Brown Update. Issue 2 March 2005).

When talking about involving schools in HUNCH, Zeek said, “Once we got them out of that textbook, they just went off. They’re making their own decisions. They’re coming up with new off-the-cuff ideas of how to do things. It’s a win-win situation for the schools and for NASA” (Students to design training mockups for NASA astronauts, by Belissa Bonds, Daily Mountain Eagle Jasper Alabama, January 14, 2008).

Tammy Rowan, manager of Marshall Space Flight Center’s Academic Affairs Office, told reporters about the HUNCH Ares 1 project by saying, “The project allows today’s bright young minds direct access to NASA people and projects, engaging and preparing them to lead the nation’s laboratories and research centers of tomorrow” (Next Generation Has a HUNCH for Next Gen Rocket Satnews Daily February 6, 2009 retrieved online from [www.satnews.com](http://www.satnews.com) on 2/23/2009).

**Diversity**

The HUNCH program seeks out a diverse population of schools and students. It aims to provide students in technical classes the opportunity to be exposed to engineering tasks and professionals.

**Procedures**

1. Contact district Career and Technology Education (CATE) director
2. Visit schools to assess capabilities
3. Verify with administration and teachers the desire to commit to the HUNCH program
4. Assign tasks to schools according to their capabilities
5. Supply materials, drawings, and technical assistance

6. Schools enter a Space Act Agreement with NASA. (This is a legal agreement signed by the super-intendant of the school district with NASA. The schools cannot hold NASA responsible for any injury of students while working at school on a NASA project. NASA expects schools to supply a safe working environment and instructional oversight for students.
7. There is no application to fill out to participate in the HUNCH program
8. HUNCH projects are collected by NASA when completed
9. Summer internships and training of teachers and students are available
10. Award Assemblies and VIP tours of Johnson Space Center or Marshall Space Flight Center are available for all students and teachers involved in the HUNCH program

## **Content Standards**

There are 20 content standards for the International Technology Education Association (ITEA). HUNCH projects involve ten of these standards. The following are copies of these standards.

### **“Design**

Standard 8. Students will develop an understanding of the attributes of design.

Standard 9. Students will develop an understanding of engineering design.

Standard 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem-solving.

### **Abilities for a Technological World**

Standard 11. Students will develop abilities to apply the design process.

Standard 12. Students will develop abilities to use and maintain technological products and systems.

Standard 13. Students will develop abilities to assess the impact of products and systems.

### **The Designed World**

Standard 16. Students will develop an understanding of and be able to select and use energy and power technologies.

Standard 17. Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19. Students will develop an understanding of and be able to select and use manufacturing technologies.

**Federal  
Definition of  
Vocational  
and  
Technical  
Education**

Standard 20. Students will develop an understanding of and be able to select and use construction technologies. (Retrieved 01/10/2009 from <http://www.iteaconnect.org/TAA/PDFs/ListingofSTLContentStandards.pdf>)

HUNCH projects provide what is stated as vocational and technical education activities. The following is a copy of the definition.

**Federal Definition:**

**“Vocational and Technical Education.** – The term “vocational and technical education” means organized educational activities that-

A. Offer a sequence of courses that provides individuals with the academic and technical knowledge and skills the individuals need to prepare for further education and for careers (other than careers requiring a baccalaureate, master’s, or doctoral degree) in current or emerging employment sectors; and

B. Include competency-based applied learning that contributes to the academic knowledge, higher-order reasoning, and problem-solving skills, work attitudes, general employability skills, technical skills, and occupation-specific skills, of an individual”

(Retrieved 01/10/2009 from <http://www.iteaconnect.org/TAA/PDFs/ListingofSTLContentStandards.pdf>).

APPENDIX D

MISSION SPACE: RESEARCH DESIGN A GROWTH CHAMBER  
TO PROVIDE FOOD FOR LONG DURATION MISSIONS.  
NATIONAL LAB / HUNCH 2009-2010

## Plant Growth Chamber

Objective: Primary, to design and build an experiment for the International Space Station.  
Secondary, to fabricate Single Stowage Lockers for Astronaut training at JSC.

Goals: Machining: Fabricate one or more Single Stowage Lockers  
Automotive Body Repair: Paint one or more Single Stowage Lockers  
Automotive Engine Repair: Assemble one or more Single Stowage Lockers  
Quality Assurance?: Inspect the piece parts and assembled project.  
AP Biology: Design a growth chamber that will fit in a Single Stowage Locker  
AP Physics: Design a growth chamber that will fit in a Single Stowage Locker  
Engineering Design: Draw a growth chamber that will fit in a Single Stowage Locker  
Electronics: Design a growth chamber electrical components that will fit in a Single Stowage Locker  
Family and Consumer Science: Make part of a meal with the items from the growth chamber.  
Wood shop: Fabricate a test fixture growth chamber to grow items in the class room  
Journalism: To gather weekly status, document process, to tell the story  
Logistics/Project Management: Maintain a schedule and provide weekly status reports for all parties

Documentation: Single Stowage Locker Drawings  
EXPRESS rack utilities and connections  
NASA electronic standards  
International Space Station Kitchen capabilities

Logistics / Project Management will be managed at the College Level and may not have a high school counterpart. All other areas there should be significant contributions at the high school level. I would also like to see opportunities were middle school students to participate.

If all goes well, then later we will be looking at making the flight article.

Responsibilities:

Machining:

Machine the parts needed to build the locker  
Determine raw material needed to build the locker  
Determine the consumables needed to build the locker  
Report weekly progress

## Automotive Body Repair:

- Paint the parts of the locker that are required to be painted
- Determine raw material needed to paint the locker
- Determine the consumables needed to paint the locker
- Report weekly progress

## Automotive Engine Repair:

- Assemble the Locker
- Determine hardware needed to build the locker
- Determine the consumables needed to build the locker
- Report weekly progress

## Quality Assurance?:

- Coordinate with Machining and inspect finished parts
- Coordinate with Painting and inspect finished parts
- Coordinate with Engine Repair and inspect sub-assemblies and final assembly
- Report weekly progress

## AP Biology:

- Grow the items in the test fixture, experiment.
- Determine nutrients to be added and how
- Hydroponics or soil?
- Growth chamber orientation?
- Light source?
- What are you going to grow?
- Report weekly progress
- Experiment results

## AP Physics:

- How are gases going to mix?
- How are liquids going to mix?
- How are solids going to mix?
- How are the items going to be harvested?
- Report weekly progress
- Experiments results

## Engineering Design:

- Coordinate with AP Biology and AP Physics to design and draft a growth chamber.
- Design both the growth chamber that will fit into the locker and a test fixture made of wood
- Coordinate with Family and Consumer Science on the design of food processing glove box.
- Report weekly progress

## Electronics:

- Design electronics that will be safe in a wet environment for both the locker and test fixture
- Determine hardware needed to build the locker

Determine the consumables needed to build the locker

Fabricate electrical for locker and test fixture

Report weekly progress

Family and Consumer Science:

Coordinate with AP Biology and determine what will be grown

Food preparation plan, do we need to design a food processing glove box?

Provide nutritional information report.

Plan on feeding seven astronauts at this meal.

Report weekly progress

Wood shop:

Determine hardware needed to build the test fixture

Determine the consumables needed to build the test fixture

Fabricate a prototype growth chamber (test fixture) to grow items in the class room

Report weekly progress

Journalism:

Gather weekly status,

Document process, to tell the story

Photo document students and project

Report weekly progress

Logistics/Project Management:

Maintain a schedule

Track tasks through completion (cost and hours)

Collect weekly reports for all parties and provide a consolidated report to

NASA

Collect and distribute information to the team.

Coordinate media events with school district, NASA and media.



APPENDIX E

FOCUS GROUP AND INTERVIEW QUESTIONS

## Focus Group Questions

Focus group questions dealing with research question 1 on how HUNCH students perceive STEM courses

1. How does your STEM HUNCH class compare to your other high school classes?
2. After being in the HUNCH program, how have your feelings about the relevance of science classes changed?
3. How has the HUNCH program changed your attitude toward high school science classes?
4. What are three benefits of the HUNCH class?
5. Do you have a different view of the importance of science and math classes after being in HUNCH? Why?
6. Do you find your math and science education more useful after being involved in HUNCH? If so why?
7. How does your STEM HUNCH class compare to your other math and science classes?
8. How does your self confidence to do well in your STEM HUNCH class compare to your other classes?
9. How has your STEM HUNCH class made you feel about your ability in science?
10. How does your freedom to make choices about what you do in your STEM HUNCH class compare to other classes?
11. How has your STEM HUNCH class influenced your enjoyment of science classes?
12. How useful are the things you learn in your STEM HUNCH class to everyday life?
13. How would you compare your anxiety level in your STEM HUNCH class to your other classes?
14. How has your motivation for studying math and science changed since being in the HUNCH program?
15. What is your biggest motivating factor to study science and how has HUNCH influenced this factor?

Focus group questions dealing with research question 2 on how HUNCH students perceive STEM courses

16. What are your future plans after high school?
17. Has the HUNCH program influenced your future career plans?

Focus group questions dealing with what learning experiences HUNCH students describe as motivating them toward pursuing courses and careers in STEM areas.

18. Why did you enroll in the HUNCH class?
19. Describe 3 aspects of HUNCH that are particularly valuable or interesting to you and why?
20. What specific activities of the HUNCH program did you like best and which did you like least?

21. Has anyone in your family been involved with space, science, math, engineering as a career or hobby?
22. How is the HUNCH program influencing your decisions to enroll in higher-level math and science courses in high school?
23. How has the HUNCH program influenced your future career plans?
24. What is your biggest motivating factor to study science and how has HUNCH influenced that factor?
25. Do you find your math and science more useful after being involved in HUNCH, if so why?

Focus group questions dealing with student perceptions of the HUNCH program?

26. Describe three aspects of HUNCH that are particularly valuable or interesting to you and why?
27. Why did you enroll in the HUNCH program?
28. How does HUNCH class compare to your other math and science classes?
29. What do you like least about the HUNCH program?
30. What do you like most about the HUNCH program?
31. Name three characteristics that a successful HUNCH teacher needs?
32. Do you have any suggestions on how to improve the HUNCH program?
33. Has anyone in your family been involved with space, science, math, or engineering as a career or hobby?
34. What are three benefits of the HUNCH program?
35. What specific activities of the HUNCH program did you like best and which did you like least?
36. Describe three aspects of HUNCH that you would like to eliminate and why?
37. What does HUNCH stand for?
38. What is your biggest motivating factor to study science and how has HUNCH influenced that factor?
39. How has your motivation for studying math and science changed since being in the HUNCH program?
40. How often have you stayed late or put in extra hours to work on a HUNCH project?

## Interview Questions

Interview questions dealing with Research question 1 on how HUNCH students perceive STEM courses

1. How has the HUNCH program influenced your enrollment in science courses?
2. After being in the HUNCH program has the relevance of your science education changed?
3. How has the HUNCH program influenced your enrollment in math courses?
4. After being in the HUNCH program has the relevance of your math education changed?
5. How does your STEM HUNCH class compare to your other high school classes?
6. How has the HUNCH program changed your attitude toward high school science classes?

Interview questions dealing with research question 2 on how HUNCH students perceive STEM careers

7. What are your future plans after high school?
8. Has the HUNCH program influenced these plans?
9. How has HUNCH influenced your career goals?

Interview questions dealing with what learning experiences HUNCH students describe as motivating them toward pursuing courses and careers in STEM areas.

10. What do you like most about the HUNCH program? Describe three aspects of HUNCH that are particularly valuable or interesting to you and why?
11. What is your biggest motivating factor to study science and how has HUNCH influenced that factor?
12. How has the HUNCH program changed your attitude toward high school science classes, toward science and space exploration in general?
13. What aspects of the HUNCH program do you feel motivates your students the most and why?
14. How do you feel that the HUNCH program influences your students' perception of pursuing careers in science or STEM areas?

APPENDIX F

PRINCIPAL'S CONSENT FORM FOR PARTICIPATION  
IN HUMAN RESEARCH AT MONTANA STATE UNIVERSITY

PRINCIPAL’S CONSENT FORM FOR PARTICIPATION IN HUMAN RESEARCH  
AT MONTANA STATE UNIVERSITY

**The Influence of the HUNCH (High School Students United with NASA to Create Hardware) Program on Student Motivation to Study and Pursue Careers in Science**

Your school is being asked to participate in a study on the motivational constructs of the HUNCH program. This research is for a doctoral thesis conducted through Montana State University in Bozeman, Montana. The purpose of this study is to evaluate the influence of the HUNCH program on student motivation to study and pursue careers in science. This research is designed to answer the following questions (1) Do students who participate in the HUNCH program express positive perceptions toward studying science in high school? And (2) Do students enrolled in the HUNCH program express positive perceptions toward pursuing scientific careers? If you give permission for this study to be conducted in your school, please read and sign this form.

Each participant will be asked to respond to survey questions and from these survey responses, a group of 10-12 students will be further asked to take part in interviews. The interviews may be audio taped. Participants will be asked to express their opinions about how the HUNCH program has influenced their educational goals.

All data collected will be confidential and handled according to the guidelines of the Internal Review Board of Montana State University. These guidelines prohibit the identification of participants to anyone except the researcher and her faculty advisor.

There are no known risks or benefits for the participants of this study.

Your school’s participation in this study is voluntary and the school may withdraw from the study at anytime by contacting Florence Gold at (406) 690-2661. Please feel free to call Florence Gold at any time with questions or concerns. Additional questions about the rights of human subjects can be answered by writing to Chairman of the Institutional Review Board, Mark Quinn, 960 Technology Blvd., Room 127, Bozeman, MT 59717 or by calling Mark Quinn at (406) 994-4707.

---

**AUTHORIZATION: Your signature below indicates your school’s voluntary agreement to participate in this study.**

I have read the above description of this research study. I am aware of the voluntary nature of this study, and I know how to get any further questions answered. I voluntarily agree to allow my school to take part in this study. I understand that I will receive a copy of this consent form.

Participant’s Signature: \_\_\_\_\_ Date \_\_\_\_\_

Witness: \_\_\_\_\_ Date \_\_\_\_\_

Investigator: \_\_\_\_\_ Date \_\_\_\_\_

APPENDIX G

SUBJECT CONSENT FORM FOR PARTICIPATION IN  
HUMAN RESEARCH AT MONTANA STATE UNIVERSITY  
AND IRB APPROVAL

SUBJECT CONSENT FORM FOR PARTICIPATION IN HUMAN RESEARCH AT MONTANA STATE UNIVERSITY

**The Influence of the HUNCH (High school students United with NASA to Create Hardware) Program on Student Achievement in Math and Science**

You are being asked to participate in a study on the motivational factors of the HUNCH program. This research is for a doctoral thesis conducted through Montana State University in Bozeman, Montana. The purpose of this study is to evaluate the influence of the HUNCH program on student motivation to study and pursue careers in science. This research is designed to answer the following questions (1) Do students who participate in the HUNCH program express positive perceptions toward studying science in high school? And (2) Do students enrolled in the HUNCH program express positive perceptions toward pursuing scientific careers? If you choose to participate in this study, please have you and a guardian read and sign this form and return it promptly to your teacher. You must have this form signed and returned before participating.

Each participant will be asked to respond to survey questions and from these survey responses, a group of 10-12 students will be further asked to take part in interviews. The interviews may be audio taped. Participants will be asked to express their opinions about how the HUNCH program has influenced their educational goals.

All data collected will be confidential and handled according to the guidelines of the Internal Review Board of Montana State University. These guidelines prohibit the identification of participants to anyone except the researcher and her faculty advisor.

There are no known risks or benefits for the participants of this study.

Your participation in this study is voluntary and will have no effect whatsoever, your grade for HUNCH class. You may withdraw from the study at anytime by contacting Florence Gold at (406) 690-2661. Please feel free to call Florence Gold at any time with questions or concerns. Additional questions about the rights of human subjects can be answered by writing to Chairman of the Institutional Review Board, Mark Quinn, 960 Technology Blvd., Room 127, Bozeman, MT 59717 or by calling Mark Quinn at (406) 994-4707.

---

**AUTHORIZATION: Your signature below indicates your voluntary agreement to participate in this study.**

I have read the above description of this research study. I am aware of the voluntary nature of this study, and I know how to get any further questions answered. I voluntarily agree to take part or to have my child take part in this study. I understand that I will receive a copy of this consent form.

Participant's Signature: \_\_\_\_\_ Date \_\_\_\_\_

If participant is under 18 Participant's Guardian Signature: \_\_\_\_\_

Date \_\_\_\_\_ Witness: \_\_\_\_\_

Date \_\_\_\_\_ Investigator: \_\_\_\_\_

Date \_\_\_\_\_





**INSTITUTIONAL REVIEW BOARD**  
**For the Protection of Human Subjects**  
**FWA 0000165**

960 Technology Blvd. Room 127  
c/o Veterinary Molecular Biology  
Montana State University  
Bozeman, MT 59718  
Telephone: 406-994-6783  
FAX: 406-994-4303  
E-mail: cherylj@montana.edu

*Chair:* Mark Quinn  
406-994-4707  
mquinn@montana.edu  
*Administrator:*  
Cheryl Johnson  
406-994-6783  
cherylj@montana.edu

**MEMORANDUM**  
.....

**TO:** Florence Gold  
**FROM:** Mark Quinn *Mark Quinn CJ'*  
Chair, Institutional Review Board for the Protection of Human Subjects  
**DATE:** August 17, 2010  
**SUBJECT:** *The Influence of the HUNCH (High school students United with NASA to Create Hardware) Program on Student Achievement in Math and Science Courses [FG091208]*

Thank you for submitting the follow-up report on the above research project. Reapproval of this project for an additional year will be reflected in the minutes of the next Institutional Review Board meeting. In the meantime, work on the project may continue. At the end of this approval period you will receive another follow-up form which will be used to evaluate this proposal for renewal. If the project extends beyond five years, you will need to submit a new application. Please keep track of the number of subjects who participate in the study and of any unexpected or adverse consequences of the research. If there are any adverse consequences, please report them to the committee as soon as possible. If there are serious adverse consequences, please suspend the research until the situation has been reviewed by the Institutional Review Board.

Any changes in the human subjects aspects of the research should be approved by the committee before they are implemented

It is the investigator's responsibility to inform subjects about the risks and benefits of the research. Although the subject's signing of the consent form, documents this process, you, as the investigator should be sure that the subject understands it. Please remember that subjects should receive a copy of the consent form and that you should keep a signed copy for your records.

In one year, you will be sent a questionnaire asking for information about the progress of the research. The information that you provide will be used to determine whether the committee will give continuing approval for another year. After initial approval, if the research is still in progress beyond a 5-year period, a completely new application will be required.

APPENDIX H

STUDENT INTERESTS AND MOTIVATION  
IN SCIENCE QUESTIONNAIRE

Student Questionnaire about Science Classes

Student code # \_\_\_\_\_ student gender \_\_\_\_\_ graduating class year \_\_\_\_\_ number of science courses taken in high school (include this course) \_\_\_\_\_ average grades in science classes \_\_\_\_\_

\*\*\*\*\*

Name of class that is involved with HUNCH \_\_\_\_\_ Number of semesters you have been in a HUNCH class (circle answer) 1 semester 2 semesters 3 semesters 4 semesters more than 4 semesters.

\*\*\*\*\*

When the question says "science classes" or science, please consider all your science classes from 7th grade to this present class. Only when "this science class" is written do you use the class that you are taking this questionnaire in to answer the question.

Please use the space below for comments

1) How often are science classes boring?
1) Always 2) Often 3) Sometimes 4) Seldom 5) Never

2) How often are science classes fun?
1) Always 2) Often 3) Sometimes 4) Seldom 5) Never

3) How often are science classes interesting?
1) Always 2) Often 3) Sometimes 4) Seldom 5) Never

4) How often do you like to go to science class?
1) Always 2) Often 3) Sometimes 4) Seldom 5) Never

5) How often does science make you curious?
1) Always 2) Often 3) Sometimes 4) Seldom 5) Never

6) How often do you enjoy science laboratory work?
1) Always 2) Often 3) Sometimes 4) Seldom 5) Never

7) How often have the things you studied in this science class been too easy?
1) Always 2) Often 3) Sometimes 4) Seldom 5) Never

8) How often has this science class made you feel confident?
1) Always 2) Often 3) Sometimes 4) Seldom 5) Never

9) How often has this science class made you feel successful?
1) Always 2) Often 3) Sometimes 4) Seldom 5) Never

10) How often has this science class made you feel uncomfortable?
1) Always 2) Often 3) Sometimes 4) Seldom 5) Never

11) How often has this science class made you feel unable to understand?
1) Always 2) Often 3) Sometimes 4) Seldom 5) Never

12) How often has this science class made you feel stupid?
1) Always 2) Often 3) Sometimes 4) Seldom 5) Never

13) How often has *this science class* made you feel unhappy?

- 1) Always          2) Often          3) Sometimes      4) Seldom      5) Never

\*\*\*\*\*

**How often have you done each of the following for *this science class***

14) Chosen topic or project yourself?

- 1) Always          2) Often          3) Sometimes      4) Seldom      5) Never

15) Chosen the way you want to learn?

- 1) Always          2) Often          3) Sometimes      4) Seldom      5) Never

16) Selected the order in which you study science topics?

- 1) Always          2) Often          3) Sometimes      4) Seldom      5) Never

17) Had the chance to work at your own pace?

- 1) Always          2) Often          3) Sometimes      4) Seldom      5) Never

18) Had the chance to decide when to hand in assignments and take tests?

- 1) Always          2) Often          3) Sometimes      4) Seldom      5) Never

\*\*\*\*\*

**How often have you done each of the following in your free time for *science classes*?**

19) Read articles on science-related topics in magazines?

- 1) Always          2) Often          3) Sometimes      4) Seldom      5) Never

20) Read articles on science-related topics in newspapers?

- 1) Always          2) Often          3) Sometimes      4) Seldom      5) Never

21) Watched science-related shows on TV?

- 1) Always          2) Often          3) Sometimes      4) Seldom      5) Never

22) Gone to hear people give talks on science?

- 1) Always          2) Often          3) Sometimes      4) Seldom      5) Never

23) Read books about science topics or scientists?

- 1) Always          2) Often          3) Sometimes      4) Seldom      5) Never

24) Talked about science topics with your friends?

- 1) Always          2) Often          3) Sometimes      4) Seldom      5) Never

25) Done science projects?

- 1) Always          2) Often          3) Sometimes      4) Seldom      5) Never

26) Worked with science-related hobbies?

- 1) Always          2) Often          3) Sometimes      4) Seldom      5) Never

\*\*\*\*\*

27) How often have the things you studied in *science classes* been relevant to another school subjects?

- 1) Always          2) Often          3) Sometimes      4) Seldom      5) Never

28) How often have the things you studied in *science classes* related to things you have learned outside of school?

- 1) Always            2) Often            3) Sometimes    4) Seldom        5) Never

29) Science classes are useful?

- 1) Always            2) Often            3) Sometimes    4) Seldom        5) Never

30) Much of science classes are useful in every day life?

- 1) Always            2) Often            3) Sometimes    4) Seldom        5) Never

\*\*\*\*\*

**How much do you agree with each of the following statements regarding your career?**

31) I would like to be a scientist

- 1) Strongly Agree    2) Agree            3) Neutral           4) Disagree        5) Strongly Disagree

32) I would not like a job in a science laboratory

- 1) Strongly Agree    2) Agree            3) Neutral           4) Disagree        5) Strongly Disagree

33) I would like to work with people who make discoveries in science

- 1) Strongly Agree    2) Agree            3) Neutral           4) Disagree        5) Strongly Disagree

34) A job as a scientist would be interesting

- 1) Strongly Agree    2) Agree            3) Neutral           4) Disagree        5) Strongly Disagree

35) A career in science would not be interesting

- 1) Strongly Agree    2) Agree            3) Neutral           4) Disagree        5) Strongly Disagree

APPENDIX I

HUNCH SCHOOLS FOR 2009-2010 SCHOOL YEAR

Schools in Alabama

- \*Ernest Pruitt Center of Technology, Hollywood, AL
- \*Huntsville Center of Technology, Huntsville, AL
- \*Limestone County Career Technology Center, Limestone, AL
- \*Madison County Career Technical Center, Madison AL
- Oakwood Academy High School, Huntsville, AL
- \*Walker County Career Technology Center, Jasper, AL
- Trussville High School, Birmingham, AL
- DTC, Dothan, AL
- Bob Jones High School, Madison, AL
- Brewbaker High School, Montgomery, AL

Schools in Colorado

- Warren Tech High School, Lakewood, CO

Schools in Montana

- \*Laurel High School, Laurel, MT

Schools in South Dakota

- Western Dakota Tech, Rapid City, SD

Schools in Tennessee

- \*Lincoln County High School, Fayetteville, TN

Schools in Texas

- Conroe High School, Conroe, TX
- \*Clear Creek High School, League City, TX
- Clear Springs High School, League City, TX
- \*Cypress Woods High School, Houston, TX
- Spillane Middle School, Houston, TX
- \*Cypress Ranch High School, Houston, TX
- Kahla Middle School, Houston, TX
- Galena Park High School, Houston, TX
- Barbra Jordan High school, Houston, TX
- Austin High School, Houston, TX
- Sterling High School, Houston, TX

Schools in Wyoming

East High School, Cheyenne, WY

Campbell County High School, Gillette, WY

\*Schools with an asterisk participated in research.