The Importance of Health Literacy Programs at the High School Level

The Importance of Health Literacy Programs at the High School Level

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Abstract

The purpose of this research was to investigate the effectiveness of a unique health literacy program titled MEDscience and to gain an understanding of the current state of health education and student health literacy in high school graduates. The prevalence of health conditions are high and health education programs are inconsistent, causing many young adults to enter our society lacking knowledge and skills essential for disease prevention and healthy habits, as well as properly managing health conditions and effectively communicating with healthcare professionals. Education and development of both knowledge and skills are necessary to address this poor health literacy, but it must be done in a way that allows students to practice these skills and utilize the knowledge, making the education more realistic and applicable. This study measured the effectiveness of the MEDscience program, developed by Harvard Medical School (HMS) on improving health literacy (AIM I), as well as evaluate the current state of health education, both implicit and explicitly (AIM II), and finally to assess the relationship between participation and the improvement of health literacy in students taking the program (AIM III). Student health literacy was determined for three groups, non-MEDscience, pre-MEDscience, and post-MEDscience using the MEDscience Test for Content and MEDscience: *The Experience* formative assessment. The condition of health education across difference schools was investigated through faculty survey. The MEDscience program was found to be an effective tool that demonstrated positive gains in health literacy both when compared to non-MEDscience students as well as pre-

MEDscience students; gaps in current health education curriculum across schools as compared to the National Health Science Standards.

Author's Biographical Sketch

The author is a 2005 graduate from St. Lawrence University with a degree in Biology. After earning her post-baccalaureate teaching credentials at the University of Colorado, Boulder, Emilia started teaching high school life science at an independent school in the Boston area. She has been teaching biology, AP biology, and anatomy and physiology-based electives for the past 9 years. In additional to teaching she is chair of her department, developed curriculum, and been a peer teaching coach. Through her myriad interactions with students, she had been surprised by their limited health literacy and the lack of opportunity students have to improve upon it. In 2014, she decided to pursue her master's degree in the field of Biology while remaining teaching, with the purpose to enhance pedagogical content knowledge and apply that knowledge to develop authentic and relevant science instruction. Around the same time, Emilia was approached by a student-parent about implementing the MEDscience program at her school. Emilia quickly recognized the value of the program and launched a MEDscience elective at her school. She utilized curriculum provided by Harvard Medical School (HMS) MEDscience and modified it to meet student and faculty requirements. Over the past 5 years, Emilia has observed and measured the positive impact the MEDScience program has had on her students' health literacy. She currently is piloting a new MEDscience program, titled MEDscienceLAB, which focuses on the genetic research side of medicine and the mastery of lab-based research techniques.

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Chapter I

Introduction

When individuals or their loved ones are not feeling well, they must make choices on how to proceed, and the stress and knowledge behind these decisions very much depends on what the individual knows about the illness and the individual's ability to properly communicate with healthcare professionals, or otherwise, the individual's health literacy. Not only when sick, one's health literacy is exercised when choices around preventative care is made, such as diet and exercise, as well as societal decisions that may impact one's health for the long term, such as family history, environmental living conditions and community. An individual could use their basic understanding of the human body and common diseases to make conscious, educated decisions, they could try to use the internet to research what to do, or they could go to a doctor or hospital for guidance. The concept of health literacy, or "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" (Ratzan and Parker, 2000), is a growing concern for our youth population based on the prevalence of health conditions and the low level of health education programs (Ratzan and Parker, 2000). Health literacy as a component of science literacy, is the reason national standards around science teaching and curriculum are developed, for example, the Next Generation Science Standards (NGSS) and the National Health Science Standards (NHSS). These standards not only look at content covered, ability to apply the content in a medical setting, but also the skills necessary for an individual to properly interpret and communicate science topics. The knowledge and skills necessary for health literacy as they relate to science literacy include dialogue and discussion, reading health information, interpreting charts, making decisions about participating in research studies, using medical tools for personal or familial health care, calculating timing or dosage of medicine, or voting on health or environmental issues (Ratzan and Parker, 2000). Our society has a set of expectations for science literacy in our graduating high school students, and therefore the expectation of health literacy must also be addressed.

The reason enhanced health literacy programs must be set in place at the high school level is because it is the final opportunity that many young adults have of receiving this guidance and education through both explicit and implicit programming required for graduation prior to being a legal adult, where they are making independent health decisions. The Digest of Educational Statistics by the Department of Education cited in 2015 that 69.2% of graduating students continue to college immediately following high school completion. In addition to that, only 17% of the bachelor's degrees conferred in 2015-15 were in fields in which students may receive more education in health literacy. Therefore 30.8% of our high school graduates and 83% of our college graduates are potentially not receiving the necessary education in prevalent health condition topics to make them equipped to deal with these conditions in our society, because they are no longer in programming where health literacy is a topic covered. (National Center for Education Statistics, 2018, ch. 3). This overwhelmingly large number doesn't include the 16% of young adults who dropped out of high school in the year 2015-16 (McFarland et. al., 2018). Fortunately, many schools still have a curriculum or program in place for health education, however many of these programs are designed to focus on topics such as healthy relationships, drugs and alcohol, emotional health, and safe sex (Massachusetts Health Frameworks, 1999). Although these topics address the priority topics for school-aged children, it still leaves a gap in the health literacy need to live a well-rounded, healthy life. As far as human systems, the only human system regularly covered in a health course being the reproductive system. Topics that are prevalent in our society, such as asthma, heart disease, diabetes and opioid abuse may be addressed very quickly or not at all. The Journal of School Health released a list in 1950 of 500 topics necessary in a health curriculum where heart disease, diabetes, and asthma were included, but other topics like bedwetting, hazards of high I.Q., and fluoridated toothpastes were listed at equal importance (Byrd, 1950). Our educators, school leaders, and those responsible for education policy need to rethink what is most important to be teaching to prepare the students for life after school, and to tailor the mandated health curriculum accordingly. The National Health Science Standards provide some guidelines for the expectation of knowledge in graduating high school students. Unfortunately, it is our belief many students and health programs fall short from reaching that standard (National Health Science Standards, 2015). If such standards cannot be met, then we cannot claim graduating students have a level of health literacy that will meet their needs to be a proficient and active member in our healthcare system. Meaning, they will not have the knowledge and skills necessary to navigate proper preventative health and any health issues that they encounter in their lives, and as a result may be more taxing to our healthcare system.

The rationale behind this research is to investigate the effectiveness of a health literacy program started by Harvard Medical School titled MEDscience, which began as a summer program in 2005 and developed into a semester-long high school program in 2008. In addition, we wanted to gain an understanding of the need of programs like MEDscience using health literacy data from graduating high school students. This program is meant to accompany a more traditional health program, and focus on pertinent health issues, such as asthma, diabetes, heart disease, and opioid abuse. A program like MEDscience should be a mandatory graduation requirement, to ensure all students are graduating with a similar level of health literacy. The standards used to measure the level of content knowledge and ability to problem solve health problems are taken from the National Health Science Standards which are designed to outline the recommended benchmarks of understanding for college or career-bound high school students (*Appendix H*). The style of teaching in the MEDscience program is unique compared to what one might find in a traditional classroom setting, allowing students to engage in many of the science and engineering practices determined by the Next Generation Science Standards (NGSS) *(Appendix J*). The NGSS are standards for learning science in the 21st century that have been categorized into three different domains: crosscutting concepts, science and engineering practices, and disciplinary core ideas (NGSS Lead States, 2013). The MEDscience program implements many of the science and engineering practices of NGSS, which are meant to describe what scientists do, how they do it, and the cognitive, social, and physical practices that this "doing science" entails (NGSS Lead States, 2013). The MEDscience program also encourages students to participate higher level of Bloom's Taxonomy (Bloom, 1956). In addition, student responses were calibrated to the cognitive domain of Bloom's Taxonomy, an established hierarchical model used to classify learning objectives by both knowledge and intellectual skills (Bloom, 1956). Bloom's Taxonomy is an important tool for teachers to consider when designing curriculum and individual lesson instruction because it enables teachers to design a lesson that requires students to utilize their brains in different ways and to promote higher forms of thinking. Teachers can use Bloom's taxonomy to assess the learning goals and objectives of each lesson to ensure that it is a rich learning experience for the student.

Definition of Terms

"Asthma": Chronic lung disease that inflames and narrows an individual's airways causing the patient to experience wheezing, shortness of breath, chest tightness, and coughing (NHLBI, access 2018)

"Bloom's Taxonomy": A set of hierarchical categories of cognitive thinking used by teachers to create lessons that encourage higher forms of thinking by their students, and to move away from predominantly rote learning (*Appendix I*) (Bloom, 1956).

"Diabetes": Group of metabolic diseases of different types, all characterized by hyperglycemia resulting from defects in either insulin secretion, insulin action on target cells, or both (Diabetes Care, 2010). Chronic diabetes can result in long-term damage, dysfunction, and failure of multiple organs in the body (Diabetes Care, 2010).

"Gallstones": Crystallization and precipitation of excess biliary cholesterol (Portincasa et al., 2006).

"Health Literacy": The cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand, and use information in ways which promote and maintain good health (Nutbeam, D. 1998).

"Healthcare Utilization": Includes office visits with both physicians and non-physicians as well as emergency room visits. (Rasu et al., 2015).

"Healthcare Expenditure": Includes all cost associated with visits (office and emergency room), as well as prescription expenditures (Rasu et al., 2015).

"Heart Disease": Includes many types of heart conditions, the most common being coronary artery disease, which lowers blood flow to the heart and can lead to a heart attack (CDC Heart Disease, access 2018).

"Hypertension": Chronic high blood pressure, meaning pressure in the blood vessels is higher than normal, which can increase the risk for heart disease and stroke (CDC High Blood Pressure, access 2018). This disease can be called the "silent killer" because it can often have no symptoms or warning signs (CDC High Blood Pressure, access 2018).

"Literacy Levels:"

"Below Basic": Indicates no more than most simple and concrete literacy levels (Kutner et al., 2013). For example, these individuals can locate easily identifiable information, locate numbers and using them to perform simple quantitative operations when math is concrete and familiar. (Kutner et al., 2013)

"Basic": Indicates skills necessary to perform simple and everyday literacy activities (Kutner et al., 2013). These individuals show the ability to read and understand information in short, commonplace prose texts, simple documents, and locating easily identifiable quantitative information and using it to solve simple, one-step problems when math is specific or easily inferred (Kutner et al., 2013).

"Intermediate": Indicates skills necessary to perform moderately challenging literacy activities. These individuals can read and understand moderately dense, less commonplace text, summarize, make simple inferences, determine cause and effect, and recognize author's purpose (Kutner et al., 2013). They can also locate information in dense, complex documents, and less familiar quantitative information to use when solving a problem with operation is not specified or inferred (Kutner et al., 2013).

"Proficient": Indicates skills necessary to perform more complex and challenging literacy activities (Kutner et al., 2013). These individuals can read, lengthy, abstract prose text, synthesize information, and make complex references (Kutner et al., 2013). They can also integrate, synthesize, and analyze multiple pieces of information located in complex documents, and locate abstract quantitative information to use towards solving multistep problems with operations are not inferred (Kutner et al., 2013).

"Next Generation Science Standards": developed by a group of 26 states in the United States to determine a set of standards that are "rich in content and practice, arranged in a coherent manner across disciplines and grades to provide all students an internationally benchmarked science education" (NGSS Lead States, 2013).

"National Health Science Standards": developed by the National Consortium for Health Science Education, this set of standards provides a clear set of industry and post-secondary expectations in health science education (*Appendix H*) (National Health Science Standards, 2015).

"Opioid": A class of drugs used to reduce pain but have serious health risks and side effects (CDC Opioid Overdose, access 2018), most notable being highly addictive. Addiction often begins with prescription opioids for pain, and then escalates to more serious opioid drugs, like heroin.

Background of Problem

Health Literacy

Health literacy, as mentioned previously, is a concept centered around the knowledge and skills an individual has regarding their or their loved one's health care. This broad topic includes the content knowledge of human systems in a healthy and diseased state, as well as the ability to self-educate when these conditions arise. To do this effectively, these individuals must have strong problem-solving skills, the ability to synthesize relevant information, and communicate effectively with healthcare professionals. It is reported that the level of reading required for many healthcare and consent documents varies widely from 5th- 10th grade (Magnani et al., 2018). The incapability to read and understand a healthcare-related document (prescription, lab analysis, treatment options, etc.) will influence how well that person utilizes the document, whether that be administering proper medication regimen, adjusting eating and lifestyle habits, or others. The Next Generation Science Standards (NGSS) have identified the importance of reading and communication, through the science and engineering practice: obtain, communicate, and evaluate information *(Appendix J)* (NGSS Lead States, 2013). The inability to understand a disease or condition is very high in the US, and has found to be associated with patient morbidity, death, healthcare use, and increased cost (Magnani et al., 2018). Limited health literacy prevents individuals and families from engaging in their care in an empowered way, because they feel they do not have the knowledge, skills, or confidence (Magnani et al., 2018).

The National Center for Education Statistics released the first ever large-scale national assessment in the United States that contained a component aimed to specifically measure health literacy in 2003 titled the National Assessment of Adult Literacy (Kutner et al., 2013). They scored adults into four different levels, below basic, basic, intermediate, and proficient. Explanations of these levels can be found in the definition of terms as well as Table 1.

Table 1. Levels of Health Literacy determined and scored by the National Assessment of Adult Literacy (Kutner et al., 2013)

Level	Explanation of Skill	Example
Below Basic	No more than most simple and concrete	Individuals can: ● locate easily identifiable information ● locate numbers ● perform simple quantitative operations when math is familiar and concrete
Basic	Simple and everyday literacy activities	Individuals can: ● read and understand information in short, commonplace prose texts and simple documents ● locate easily identifiable quantitative information ● solve simple, one-step problems with math is specific or easily inferred.
Intermediate	Moderately challenging literacy activities	Individuals can: ● read and understand moderately dense, less commonplace text, summarize, make simple inferences, determine cause and effect, and recognize author's purpose ● locate information in dense, complex documents ● use less familiar quantitative information to use when solving a problem with operation is not specified or inferred
Proficient	Perform more complex and challenging literacy activities	Individuals can - read, lengthy, abstract prose text, synthesize information, and make complex references - integrate, synthesize, and analyze multiple pieces of information located in complex documents - locate abstract quantitative information to use towards solving multistep problems with operations are not inferred

This assessment reported most adults (53%) had intermediate health literacy, 22% had basic health literacy, and 14% had below basic health literacy. More alarming yet, 49% of adults who did not complete high school had below basic health literacy (Kutner et al., 2013). This data indicates 36% of our adult population have a limited health literacy, meaning they may only be able to read and understand simple documents, locate and understand information in commonplace prose texts, and solve one-step problems when the operation has been identified (Kutner et al., 2013). This population would struggle significantly when trying to help themselves or even after being seen by a doctor and diagnosed. They would also struggle to help their loved ones should they suffer from a common disease. If individuals do not understand how to prevent health problems, do not understand what is wrong, do not have the ability to recognize and understands signs and symptoms of common health conditions, they will be unprepared to help themselves or their loved ones with the conditions to arise. A compounding factor is after receiving guidance for the health condition, that they may or may not understand, individuals with a low health literacy would struggle with following instructions for proper patient care. Those individuals with limited health literacy have been proven to have a higher healthcare utilization and expenditure (Rasu et al., 2015). Therefore, health illiteracy is costing our country money. A strategy proposed has been to develop programs to educate those individuals with limited health literacy (Rasu et al., 2015), we propose to implement a robust health literacy program in conjunction with more traditional health education, at the high school level, prior to the onset of many health conditions that plague our society. Funds allocated to the implementation of this program will help close the health literacy gap and in turn, reduce healthcare expenditure.

With adult health literacy a growing concern, the time at which to educate our society is before they graduate high school. It has been proven that adolescents are interested in learning about health issues and want to be involved in their health decisions (Brown et al., 2007), therefore high school is an opportune time to harness this interest and educate them. If the lack of health literacy is not addressed prior to students graduating from high school through increased implementation of required health literacy programming, then a large portion of the population who are not furthering their education in health-related professions will not be reached. This leads to young adults who soon become adults with families of their own, still lacking the health literacy required to make informed decisions about health care.

Online Educational Health Literacy Resources

With the dramatic rise in both information and the accessibility of the internet, many individuals have begun to use the internet as a reliable source for healthcare information, diagnoses, and treatments. Hansberry et al (2015) states that according to many studies, 63% of US internet users rely on the internet as a source of health care information. The reasons range from recent diagnosis of a medical condition, recent prescription to a new medication (Hansberry et al., 2015), or simply to learn about new symptoms someone may be experiencing. The problem with relying on the internet is that much of the information found may be taken out of context, or from an unreliable source. If we could improve individual's health literacy, then perhaps they could use the internet as a research tool to make more informed decisions about preventative care and avoid unnecessary trips to a physician's office. If a patient is sick, the recommended way to learn this information is still through a patient-physician discussion, which would allow the patient to make more informed decisions about their health care (Hansberry et al., 2015). However, this is assuming an individual has the level of health literacy required to have a productive effective conversation with their physician. Another way to combat the misguided advice from the internet is by providing opportunities for young adults to learn about common health issues in the classroom, from qualified teachers, in a meaningful environment. The program in this study, MEDscience, and others like it, teach high school students about common health conditions that are prevalent in our society and therefore they may face in their lifetime through a unique program that hybrids classroom work with an experiential-based, fieldwork experience, meant to inspire and intrigue students. The pedagogy pushes students to problem solve, think critically, and communicate with healthcare professionals. This information is taught by qualified doctors, nurses, teachers, and medically trained volunteers. Programs like these will help individuals be self-advocates and make informed healthcare decisions, not based on the internet, and combat health illiteracy in our future generations.

Health Education Programs

Health education programs must change with how our society views health and the prevalence of health conditions. Currently, health education is implemented explicitly in a variety of ways over the course of the student's first few years of high school and is not always a required course for graduation (site my data?). Each US state issues health curriculum frameworks, which are a set of guidelines for schools to use when building their health education programs. In Massachusetts, educational policy states that health education should include topics such as alcohol, nutrition, safety, dental health, body systems and many others, but it also states that no pupil should be required to take a course based on disease, conditions, and treatment when the parent of such pupil objects in writing (Massachusetts Comprehensive Health Curriculum Framework, 1999). As new or different conditions become more widespread, educators must adjust health education curricula and reconsider the level of implementation of disease conditions and prevention to accommodate these changes to maintain health literacy in graduating students. Health education in the 1960's and 1970's focused on prevention of non-communicable disease through the lens of promoting a healthy lifestyle (Nutbeam, D. 2000). A low level of understanding was required, no consideration for the social and economic circumstances the students were in was given, or how those circumstances may affect or drive the understanding of healthy lifestyles. This style of teaching health was found to be most effective on the more educated and literate populations (Nutbeam, D. 2000). In the 1980's health education shifted to theory-informed interventions, considering the social context of decision making, and providing practical guidance for making healthy behavioral decisions (Nutbeam, D. 2000). Much of the healthy lifestyle focus in a health education programs stems around sexual relationships, consent, drugs, and alcohol. Much less of the health program covers common health conditions, prevention, and early signs for those conditions. We still very much rely on our physicians and medical community to guide us.

Keep in mind, high school students are also gaining knowledge about the human body implicitly through other science courses. Most schools require some variety of course based on life science at the high school level for graduation, and oftentimes this course covers one or more human body system. Many students go on to take additional life science courses that may cover human systems more thoroughly, and even mention them in the diseased state. The issue with the implicit learning as it relates to health literacy is it is inconsistent among our graduating students. Therefore, we cannot rely on other courses, such as Biology, to cover topics related to human health conditions and prevention at the level in which is necessary to improve our societies health literacy. These topics need a space and curriculum where they are taught explicitly, with real-world connections to improve health literacy and better prepare future adults of our society.

The MEDscience Program

The MEDscience program, designed by Harvard Medical School, is designed to engage and inspire students through science, deepen classroom knowledge, and build self-efficacy and 21st century skills (MEDscience, n.d.). In class, students are given background knowledge of human anatomy systems, and then required to use this knowledge in a real-life emergency room simulation at HMS to diagnose a patient. The students work together to collect information from the patient, critically think about potential diagnoses, and then order and analyze medical tests to arrive at a conclusion. What makes the MEDscience program unique is that it uses disease as a context for teaching human systems, covering many topics not seen in a typical health education program. This experiential, case-study based, team-work oriented program puts the challenge on the students to use their knowledge of human systems to work with a patient and figure out what may be wrong. Once students have solved the case, they are debriefed about the disease, how it can be treated, prevented, and warning signs that are helpful hints to know about each condition. Some sessions were skills-based sessions where students worked with one another and the professionals to master a skill, for example intubation and suturing. The importance of students learning the diseases covered in this program is evident from the high prevalence of these diseases on our society, and by educating individuals about these conditions, it empowers students to make smart healthcare decisions, and enable them to help themselves or loved ones who may be suffering, hence, improving their health literacy. The prevalence of the conditions include asthma at 7.6%, heart disease at 11.7%, hypertension 33.5%, diabetes at 12.6% and 9.6%, gallstones at 15%, and opioids which caused 33,000 accidental deaths in 2015, an increase of 54% in 16 states (CDC Features). In addition to the content knowledge, the MEDscience program also trains students to apply what they know to a real medical-based simulation which requires students to think critically, communicate, and problem solve with their teammates. This program diverges from a more traditional high school health program in content, content delivery, and student engagement, and gives students a sense of ownership and team comradery in their learning. In addition to the simulation exercises, students are also tasked with learning real medical skills, such as intubation, suturing and administering an IV. Learning these skills helps put the role of the nurse or doctor into perspective, as well as provide a common knowledge foundation between the health care professionals and the students, so that they may build a better relationship and ultimately get more out of their care. Both the simulations and skills sessions are all hands-on, experiential learning were student's problem solve in an environment where it is ok to be wrong, as long as you are willing to keep working on the problem. The advantages to this program's teaching philosophy are numerous, but most importantly it makes students excited about learning the human body, and more comfortable in their understanding about conditions that may be very prevalent to them in their future lives. In an idealistic world, MEDscience should be a portion of every current health education program to ensure our future students are graduating high school with a heightened level of health literacy, but in reality, we must think about aspects of the program that can be replicated. Not only the education of human system in a diseased state, but also the problem solving, critical thinking, and team-collaboration skills that students utilize and practice during this program.

The MEDscience program selected the diseases or conditions listed above to focus on not only because of their prevalence, but also because education and health literacy in these topics is one of the best preventative measures for someone prone or subject to these conditions. The following six topics were covered in this study: vitals, respiratory, cardiovascular, endocrine, nervous and immune. In addition to these systems, assessment of student knowledge of the diseased state focused on asthma, heart disease, and diabetes. These three topics and extremely prevalent in our society, and an improved understanding of these topics could indicate a student's heightened level of health literacy.

Asthma. Asthma is a growing concerning for our youth. It is the most frequent reason students miss school, with ⅓ of all adolescents missing school due to asthma related reasons (Krenitsky-Kron, 2011). Asthma is a chronic lung disease and cannot be cured, therefore proper knowledge on how to manage this disease is essential for a high quality of life. Because of this, programs have been put in place to promote student health literacy in asthma, however, the limited health literacy of these student's parents are perpetuating the problem. In an article that relates parental health literacy with patient care, Shone et al., reports that those parents with low HL perceived their asthmatic children as sicker that they may have been, were more worried about their child's condition, saw them as a greater burden, and had poorer interactions with healthcare providers. These low HL parents also struggle to complete paperwork, communicate with professionals, and use health materials (Shone et al., 2009). Another study cited adults believing there was a cure to asthma, and even things like yoga and dietary restrictions could be magic cures. This leads to noncompliance with regular treatment (Singh et al., 2002). Patients or parents of patients failing to stick to a medication regimen is associated with worse asthma care and outcomes (DeWalt et al., 2007). Shone et al., states that effective management requires accurate symptom recognition, skills with equipment, medication use, regimen, and knowledge of when to seek care, and that these are all more difficult tasks for individuals with low HL. Therefore, programs such as MEDscience, that teach the anatomy behind the respiratory system as it pertains to asthma, the signs and symptoms of asthma attack, as well as the treatment options are important concepts for high school students learn and experience. We must explicitly teach about these facts to avoid future generations growing up with similar misconceptions.

<u>Heart Disease.</u> The risk factors and preliminary signs for heart disease are essential in early diagnosis, management, and even prevention of heart disease. Simple modifications like diet and exercise when addressed early, can have positive outcomes for an individual managing or preventing certain types of heart disease (Aggarwal et al., 2018). The concern is the low amount of knowledge in our young adult population.

Lynch cites 65% of young adults are not aware of any factors leading to heart disease, and less than 35% recognized being overweight as a risk factor. It was found however, that those with more risk factors were more aware of the risk factors (Lynch et al., 2006). Perhaps this is due to family members suffering from the disease. This low level of knowledge indicates a low health literacy when referencing heart disease, and it has been found, despite available patient education, self-care is extremely challenging for those CVD patients with limited health literacy and decreases their quality of life (Magnani et al., 2018). Those suffering from heart disease are expected to follow complex medication and diet regimens, as well as make informed decisions about how to respond to symptoms, which is all more difficult for someone with limited skills and knowledge around what they are doing (Magnani et al., 2018). There must be educational programs like MEDscience that focus on both the content knowledge behind the heart and heart disease, as well as the skills necessary to manage and identify the disease. Education was found to be inversely associated with CHD risk (Loucks et al., 2011), and therefore it is an important step in decreasing the prevalence of it in our society.

Diabetes. Diabetes is known as the "modern epidemic" due to its increased prevalence, long course of illness, and economic burden (Patil et al., 2013). For diabetes, the awareness, and level of health literacy on the topic is correlated with English fluency (Bruce et al., 2003). It is common for individuals to associate diabetes with sugar, but this is where the literacy stops. Individuals cannot speak to whether it means too much or too little sugar, or what the actual risk factors are surrounding diet (LeClair et al., 2010). Even though the awareness in diabetes has grown, the occurrence remains high

(Mahajerin et al., 2008), and therefore diabetes must continue to be educated to our young adults.

In terms of health literacy and diabetes control, for adults with diabetes mellitus, the greater the health literacy the greater the knowledge, self-efficacy, and self-care, and therefore lower glycemic index (Dorner et al., 2012). In addition, for those with diabetes or adults with diabetic children, the greater the health literacy the more strongly those individuals adhere to the medication regimen. In short, the more the patients and patient's families know about the condition, the smarter the choices they make, and therefore the better quality of life they have. Along the same lines, Dorner et al. found that those with poor health literacy lead to weak glycemic control, and in turn poor patient satisfaction and poor patient provider communication.

As with many diseases or conditions, misconceptions around diabetes are high due to lack of knowledge (Patil et al., 2013), and these misconceptions can be the boundary between the patient or patient's family and proper management and prevention. Education on these topics helps, but it is far too late if the education begins with the patient and healthcare professional. Misconceptions and underestimation of condition can be combated with more access to health information (Dorner et al., 2012), so programs like MEDscience, which teach about the topics with the patient in mind, are extremely important.

Questions and Hypothesis

There are three aims to this study. The first is to compare the health literacy in graduating students that have taken the MEDscience program with those that have not. This aim will identify an increase in health literacy of the diseases and conditions mentioned above as well as analyze the student's ability to manage a health crisis, think critically, and problem solve with a team in those students who have taken the MEDscience program, compared to students who have not completed the program. In addition, this aim will compare the effect of self-selection on the health literacy of graduating students by comparing those students who have chosen to take the course with those that have not. This data will emphasize the need for all students to be required to take a course like MEDscience in order to ensure all students have adequate health literacy prior to graduation.

The second aim is set to compare the different approaches to teaching health literacy that currently exist across schools. Specifically, what content is covered, whether they are explicit programs such as MEDscience, compared to knowledge they learn implicitly through biology and anatomy and physiology courses. Certain human systems may be covered more often than others in lower-level science courses, giving a potential for pre-existing knowledge is some subject areas compared to others., Any additional knowledge-based assessments to compare these forms of learning will be tied to the NHSS.

The final aim is to compare growth of individual students in MEDscience programs across NHSS. The goal here is to identify areas of health literacy that are possibly more difficult for students to grasp than others. As mentioned previously, this may be, in part, because some human body topics have been covered more frequently in lower-level science courses. This aim will include a comparison between pre- and post-assessments, formative assessments taken each week, as well as a participation measurement, to correlate participation with student's level of health literacy. To summarize, the three aims are designed to identify the effect an explicit program like MEDscience has on student's health literacy and identify areas of health literacy that are especially challenging for students, with the hope to recommend programs like MEDscience to be supported and encouraged nationwide.

Implications of Research

The intention of this research is to provide evidence and reasoning for a necessary movement towards policy change surrounding content that is required in high school health programs. Awareness and education surrounding health literacy topics are a key step towards empowering our society with knowledge about prevalent conditions that will most likely impact their lives in some way. This knowledge will help them communicate with their healthcare professional, make informed decisions, and follow treatment regimens, which will ultimately improve and potentially save lives. In addition, preventative gains from improved health literacy will ultimately decrease overall healthcare costs.

Progress has been made enhancing health literacy training for healthcare professionals and their ability to deliver health care communication to patients with low health literacy (Macker et al., 2011), but why should our society rely on the health care professionals to understand and effectively communicate about our own health care? Individuals should be more aware and responsible for their own health and improving health literacy is part of that responsibility.

As mentioned previously, these topics must be addressed prior to high school graduation as it is the last time all students will have a required course list to follow. The re-formed programs would be required by all students not only those interested, to have the largest impact on our next generation of patients, physicians, parents, and family members. To be clear, this research is not stating that current health programs are not necessary, but in fact, the programs must become more robust in curriculum to adequately prepare our future generations for the health issues they may encounter within their lifetime. Implementation of programs like MEDscience, or with aspects of the MEDscience curriculum, require funding and willing professionals to educate students. Professional development for educators and collaboration with local medical professionals to use space and training tools to educate students is necessary for aspects of this program to be successful. We must inspire students to want to learn about these prevalent issues through hands-on learning and problem-solving techniques. We want to get students to think like scientists and medical professionals while problem solving medical conditions, rather than memorize a list of symptoms. Research recommends that improved health education would decrease overall health care cost (Rasu et al., 2015), we are recommending this be where the improved education be focused, as it addresses issues directly related to current healthcare issues. Knowledge is power, let's empower our future in healthcare.

Chapter II

Purpose Statement

The purpose of this study was to evaluate health literacy of graduating students against the National Health Science Standards, as well as measure the impact of the MEDscience program on increased health literacy for graduating high school students. With the ever-growing need of affordable health care, giving young individuals power through proper instruction of the human body in both a normal and diseased state as well as disease prevention instruction is vital to their growth in health literacy and a positive impact on our society. Evidence was collected to support the following three claims:

> AIM I: Programs such as MEDscience develop a student's health literacy prior to high school graduation, giving them a greater understanding with which to handle targeted health issues in their own experiences, as well be better informed with the preventative measure to avoid or combat many common diseases.
>
> AIM II: Comparison of the different approaches to health education currently being taught across schools at the high school level. Varying approaches quickly leads to inconsistency in understanding among graduating high school students.
>
> AIM III: Growth comparison of individual students participating in the MEDscience program, and given the experiential component of MEDscience, the

relationship between participation and content understanding for those students who have completed the program.

Data was collected from a variety of assessments; including formative, summative, surveys, and level of participation to evaluate the student's understanding in health literacy against the National Health Science Standards. Survey questions and student responses were compared against Bloom's Taxonomy, a hierarchical scale for cognitive thinking to evaluate the level of cognitive thought process required to understand, articulate, and make preventative decisions around certain health literacy topics.

Study Population

Data was collected in two separate trials, at the beginning and termination of the spring 2018 semester and again at the beginning and termination of the fall 2018 semester as a second trial to support statistical significance of the data collected over multiple cohorts. All students attended Yellow School, a private, non-profit, predominantly Caucasian school of middle to high socioeconomic status in New England. See chart below for trial cohort populations.

Table 2. Trial Cohort Populations

Trial	Non-MEDscience	Pre-MEDscience	Post-MEDscience
Trial One (Spring 2018)	19	28*	33* **
Trial Two (Fall 2018)	18	10***	13

*16 students completed the survey halfway through the semester. Their scores for questions were separated between the pre and post cohorts depending on whether they had covered the material in class or not.
**Cohort is slightly higher because it includes 5 students that had taken MEDscience at Yellow School before study began in 2018. Curriculum was the same.
***One of these students will be taking the course in 2019

Data for the School Health Program Survey was collected from both public and private school teachers in the United States with different health curricula (Table 3).

Table 3. Faculty and Administrator Study Population	
School type	# of participants
Private School	7
Public School	5

Ethics approval was obtained from the Committee on the Use of Human Subjects at Harvard University. All students, parents, and faculty completed the necessary consent forms for the study, found in *Appendix G*.

Study Design

AIM I: Comparative analysis of the effectiveness of the program MEDscience

This cross-sectional study compared three cohort groups of students (Table 4).

Table 4. Student Cohort Descriptions	
Cohort	Description
Non-MEDscience	These students were graduating seniors that did not choose to sign up for the MEDscience program and therefore did not complete the program.
Pre-MEDscience	Students that chose to sign up for the MEDscience program. Data collected prior to any instruction in the program.
Post-MEDscience	Students that chose to sign up for the MEDscience program. Data collected at the completion of the program.

All groups completed the *MEDscience Test for Content (MTC*) online as a google survey *(Appendix A)*. This was a one-hour test that consisted of open-response style questions designed to target the student's level of understanding of areas of the human body and analyze situations where those areas may not be healthy or working properly. The responses were evaluated based on the Health Literacy Content Knowledge Rubric (HLCKR) *(Appendix E)*. The hypothesis tested was those students who completed the MEDscience program scored higher on the MTC and therefore had an improved health literacy compared to those that had not completed the program. The manipulated variable was whether the students had completed the MEDscience program or not, the dependent variable was how high they scored on the MTC according to the HLCKR. MEDscience is a semester-long program, Non-MEDscience, Pre-MEDscience, and Post-MEDscience data was collected in two trials, spring semester of 2018 with 2018 graduates and fall semester of 2018 with 2019 graduates.

Responses to the content test were read and scored according to the HLCKR (*Appendix E*) designed to quantify the level of student's knowledge. Once all responses were quantified using the Health Literacy Content Knowledge Rubric, scores were imputed and compared between the three cohorts; Non-MEDscience students, Pre-Assessment MEDscience students, and Post-assessment MEDscience students. Average summative total scores were compared between cohort groups. Unpaired T-test was used to determine significance between cohorts for AIM I and p values were determined at a 0.05 significance, paired T-test was used between Trial 2 pre-MEDscience and post-MEDscience sub-populations and p values were analyzed at 0.05 level of significance.

Content test questions were grouped according to the standard they addressed in the National Health Standards (NHSS). Specific sub-standards were further investigated (Standard 1), which identified different areas of the human body in the healthy and diseased state. Average scores for each question were organized according to standard and substandard they addressed, to determine an overall average score for each standard and substandard. Percent increase was analyzed compared by standard and substandard across the three cohort groups.

Content test questions were also grouped according to the human body system they addressed, and average scores were compared across body system subject matter. Percent increase in average score was compared between body systems. T tests were run to determine p values at a 0.05 level of significance. Further analysis looked at the percent increase in average scores compared to the likely hood of the body system being covered implicitly in other science curriculum, data gathered from the school leader survey. In addition, student average scores were analyzed in the order in which they were taught in the curriculum, to analyze whether or not the timing of the teaching of the systems had an impact on student knowledge and improvement.

Content test questions were finally grouped according to the cognitive domain of Bloom's Taxonomy (*Appendix* I) (Bloom, 1956). Average scores on responses for three cohorts were analyzed across cognitive domains, as well as percent increase between non-MEDscience and post-MEDscience as well as pre-MEDscience and post-MEDscience were compared to see if there were more improvement in particular cognitive domains compared to others.

MEDscience Test for Content. The MEDscience Test for Content (MTC) (*Appendix A*) was built to assess students on their content knowledge of specific human anatomy topics, as well as their ability to apply this knowledge to the subject matter when it is in a diseased or altered state. Generally, questions begin with anatomical content of each system and the move to application of the content. Each question was tied to one or more of the National Health Science Standards. These standards compliment the assessment as they are designed to cover anatomical structures, diseases, medical terminology and mathematics, and well as medical communication. The series of 42 open response questions follow the same subject sequence as the curriculum, meaning the questions at the beginning of the test refer to content taught at the beginning of the program, the questions at the end of the test cover the curriculum at the end of the program. The sequence of subjects is as follows; vitals, respiratory system, cardiovascular system, endocrine system, digestive system, nervous system, and the immune system. It is important to note that some of these human systems have been taught in other health or science curriculums, while others have not. Student responses to each question were quantitatively scored against the Health Literacy Content Knowledge Rubric (*Appendix E)* for further analysis. The student responses were then organized according to which NHSS standard the question addressed, subject matter covered (human system), and level of Bloom's Taxonomy for further analysis. The MEDscience test for content was used as a Pre-MEDscience assessment tool to gather information about the baseline understanding of the student prior to completing the program as well as any implicit knowledge the student may have from other courses. MEDscience Test for Content was also used as a Post-MEDscience assessment tool, to measure the understanding of particular topics after having complete the MEDscience course.

Health Literacy Content Knowledge Rubric. To quantitatively analyze student's growth through the open responses of the MEDscience Test for Content, the Health Literacy Content Knowledge Rubric *(Appendix E)* was built to objectively assess the depth of the student response and it as an indicator of student's knowledge and/or application of the subject matter. The scale of the rubric spanned from 0-5, 0 being the student displayed no understanding of the material in their response and 5 being the student provided a detailed, accurate response that indicated an advanced and comprehensive depth in knowledge of the subject matter. The entire rubric can be found in *Appendix E*, but an example of the rubric for one question is seen below (Table 5).

Table 5. Excerpt from the Health Literacy Content Knowledge Rubric

1. Jane Miller, a 48-year-old woman, came to the emergency room complaining of a severe headache. As a medical professional, think about what you would ask Jane to help you figure out what is wrong with her. (2.1, 2.13, 2.22, 4.11, 10.11)

	National Health Science Standard	0	1 Incomplete	2 Below Average	3 Average	4 Above Average	5 Mastery
Question 1a: What type of information might help you figure out what is wrong with her?	1.21c, 8.12, 8.23		Response includes "what happened."	Brief, basic, general information. Ex. vitals, what happened	Criteria outlined in 2 in addition to history of present illness (what hurts).	Criteria outlined in 3 in addition to minimal background information on patient.	Criteria outlined in 4 as well as all background information (subjective data) on patient.

Question 1b: What information would you need about the patient's physiology and history? (INTERVIEW)	1.21c, 4.11		One test or topic. Ex. History of present illness (HPI)	Basic tests or questions. Ex. Age, weight, gender	Few tests or questions listed with no elaboration. Ex. Allergies, medication	Numerous tests, some elaboration. Ex.: Surgeries, family medical history	Multiple types of questions with elaboration covering all aspects of the patient. Ex. Vitals, patient history (allergies, social, surgical, familial, medical)
Question 1c: Describe the situation that caused these symptoms? (CONTEXT)	1.21c 2.22a		Identification of diagnosis without description. Ex. concussion	Context of situation with no description tying context to symptoms.	History of present illness described with one reason for symptoms mentioned.	Criteria outlined in 3 with two reasons for symptoms.	Full history of present illness with multiple (3+) reasons for current symptoms explained.
Question 1d: What, besides questions, might you analyze to help obtain some objective (factual) data about the patient? (VITALS)	1.21c, 1.31, 1.32, 10.11, 2.22a		1 vital mentioned	2 vitals mentioned	3 vitals mentioned	4 vitals mentioned	All 5 vitals mentioned: -blood Pressure -temperature -heart rate/pulse -respiratory rate -O2 saturation

Responses to a formative assessment titled *MEDscience, The Experience* (*Appendix D*) were collected and grouped by MEDscience session. Each experiential session covers a different system or skill associated with patient care of a human system. Student's level of comfort, confidence, and familiarity with both the content and the patient care situation were analyzed across experiential session. Student's self-assessment on level of participation was noted.

Qualitative data was collected to assess the MEDscience program in comparison to more traditional programs taught in the classroom. Student responses were gathered to get an understanding of the student perspective on this style of health literacy teaching program. Responses were classified and tallied using the MEDscience, *The Experience*

Rubric *(Appendix D)*. Students were also asked how this program could improve, or what could be done to help the student better understand the program, and these responses were used as feedback and an assessment of the success of the program.

Formative Test: MEDscience, *The Experience.* The formative test MEDscience, *The Experience* (*Appendix D*) was built to evaluate what students learned during the MEDscience experiential session at Harvard, as well as their emotions and attitudes towards the experience. The 14 question google survey consisted of both short and long open responses, as well as self-evaluation questions that were based on a scale from 0-5. Questions covered the student's level of familiarity, comfort, participation, type of participation, and what they felt was most challenging. Students also had an opportunity to compare the style of experiential learning of MEDscience to those of their other, more traditional classes. Students completed the formative test MEDscience, *The Experience* after every experiential session at Harvard Medical School (HMS), which occurred one day a week. The test was completed online as a google survey. Once data was collected open response-based questions were organized into categories for further analysis.

MEDscience, *The Experience* Rubric. This rubric was designed to classify student open responses to questions from MEDscience, *The Experience* into categories for quantitative analysis. It was developed by first reading all open responses and generating a list of categories identified (Table 6). Once categories were created, responses were tallied, and frequency of responses were determined. The entire rubric can be found in *Appendix F*, but an example of the rubric for one question can be seen below.

Table 6. Example of an open response question and the categories that were identified.		
What was most challenging for you during this session?		
Qualitative Categories	Quantitative Results (Tally, n)	Quantitative Results (%, n/total)
Skill		
Communication with patient		
Communication with team		
Problem solving, determining a diagnosis		
Environment		
Other		

AIM II: Comparative analysis of current health programs

The second aim was designed to assess the implicit and explicit ways in which health education is taught at different schools, as well as the content that is covered in the curriculum. Appropriate faculty and administrators were asked to complete a twenty-minute survey titled School Health Program Survey to gain an understanding of the type of health literacy programs being taught at their school. Survey can be found in *Appendix B*. Responses for the school health program survey were collected and grouped according to private vs. public schools, as well as content covered in mandatory vs. non-mandatory explicit health programs. This data was also used as an internal analysis of the effect implicit learning of particular systems has on the success of these human systems compared to others on the MEDscience Test for Content.

<u>School Health Program Survey.</u> The School Health Program Survey (*Appendix B*) was targeted at identifying the ways in which school health programs differ. The brief 20 question google survey was given to teachers who teach in either private and public

schools in the United States who volunteered to participate in the survey. The survey was targeted to identify if there was an explicit program, such as a health class or unit in their physical education program, what human system content was covered in the curriculum, and for how long the students are working on the material. In addition, data supporting the implicit ways for students to gain a level of health literacy in traditional science classes that were required for graduation, such as Biology, Chemistry, or Physics was collected. The survey targeted specific human anatomy content covered in both a normal and diseased state. For those who participated in a MEDscience program, the survey asked more detailed information around what topics within each human system are covered and the types of activities students engage in during class.

AIM III: Growth analysis of MEDscience students and how it relates to participation.

For those students in an explicit MEDscience program, developed by Harvard Medical School (Joyal, et al., 2014) tied to an anatomy and physiology curriculum at their school, a more in-depth data collection was administered. MEDscience students began the semester-long course by taking the one-hour content test online as a pre-assessment, to establish a baseline of their level of health literacy and knowledge of the human body prior to starting the MEDscience program. Throughout the semester-long program students were taught health literacy topics in class three times a week, and then in a hands-on, team-oriented, experiential session once per week at HMS. The experiential session at HMS required students to use the content knowledge they learned in class and apply it to a real-life emergency room simulation at HMS to try to figure out what was wrong with the patient. Some sessions were geared towards the student's mastering skills used commonly with patient care. Each of the experiential sessions required students to collaborate, work together, and think critically. During each session students were evaluated on their level of participation, based on a 0-3 scale (Table 7) on their level of different participation parameters both with the group and the patient, to correlate participation level with learning growth. Participation rubric in *Appendix C.* Student's scores were averaged for all twelve sessions, and then used along with their summative scores on the MEDscience Test for Content to determine a correlation between participation and percent increase in content knowledge.

<u>Student Participation Assessment.</u> The Student Participation Assessment (*Appendix C)* was built to gauge student participation specifically during the sessions at Harvard. Students were scored a value between 0-3.

Table 7. Student Participation Grading Rubric	
0	No participation
1	Very little participation (<2 in the experiential session)
2	Moderate participation (3-4 times in the experiential session)
3	High level of participation (5+ times in the experiential session)

Student participation was scored by the teacher during the experiential session at HMS based on whether the participation was with the patient, the professional staff, or with their peers. The assessment targeted both verbal and nonverbal participation with patient safety and proper use of terminology in mind. Each question was also linked to National Health Science Standards, to measure the student's ability to communicate effectively about human body and health related issues.

After each HMS session students were asked to complete a formative assessment titled *MEDscience; The Experience* online as a google survey (*Appendix D*) that targeted both their level of understanding of the content, as well as their comfort level with the material. At the termination of their semester-long (~4 month) program, students were given the MEDscience Test for Content again as a post-assessment. The pre- and post-assessment data was compared by student, as well as the student's level of participation, to evaluate how much growth in health literacy came from the MEDscience students, and the effect the student's level of participation and comfort had on this growth. The hypothesis tested was both experience and participation fostered higher growth in health literacy topics compared to those less participatory.

Chapter III

Results

A total of 91 MEDscience Test for Content tests were taken and analyzed in this experiment. 39 of those tests were completed by students who did not sign up for, or take the program MEDscience and were named the "Non-MEDscience" cohort. 22 students who signed up for the MEDscience program completed the MEDscience Test for Content prior to starting the program, this cohort named "Pre-MEDscience". Lastly 30 students took the MEDscience Test for Content after completion of the MEDscience program and were thus named the "Post-MEDscience" cohort.

AIM I. Effectiveness of the program MEDscience

MEDscience Test for Content Analysis

The average summative score on the MEDscience Test for Content was compared across the three cohorts (Table 8), Non-MEDscience, Pre-MEDscience, and Post-MEDscience, and a t-test was performed for significance. The average summative score for MEDscience students after completing the program (Post-MEDscience) was statistically higher than those students who did not take the course (Non-MEDscience) (Table 8) (Figure 1), with a test statistic value (p value) of $8.63\text{x } 10^{-15}$ between these two groups. The p value between the Pre-MEDscience and Post-MEDscience cohorts was $2.98\text{x}10^{-10}$, and the difference between Pre-MEDscience and Non-MEDscience students was significant (Figure 1), with a p value of $1.69\text{x}10^{-7}$ at the 0.05 significance level. In addition to average summative score, the average score across all questions was also statistically higher for Post-MEDscience students compared to Non-MEDscience students (Figure 2).

Table 8. MEDscience Test for Content summative and average scores		
Cohort	Summative Score (out of 197 possible points)	Average Score per Question (out of 5 possible points)
Non-MEDscience	28.1	0.7
Pre-MEDscience	52.9	1.3
Post-MEDscience	108	2.9

Figure 1. Average Summative Scores on MEDscience Test for Content across cohort groups

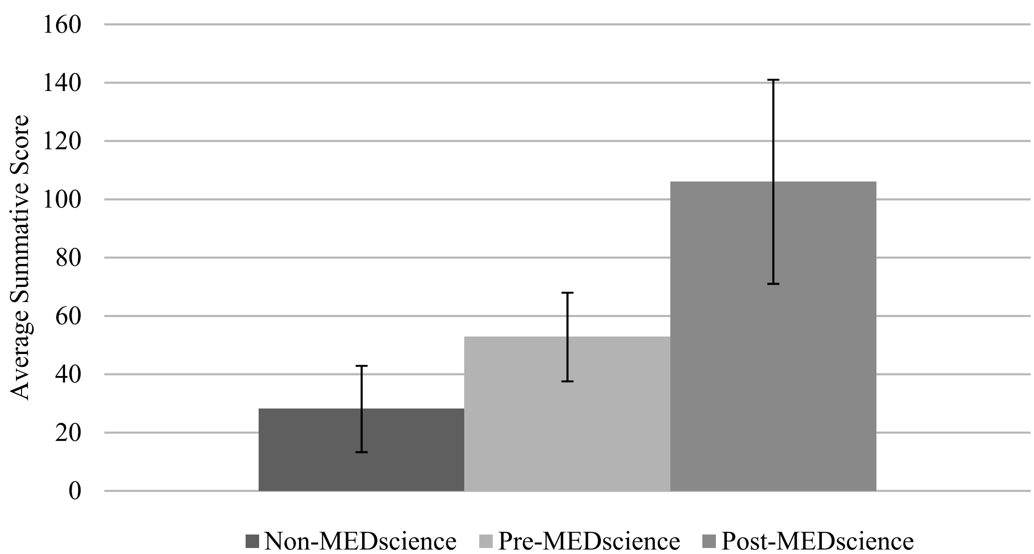
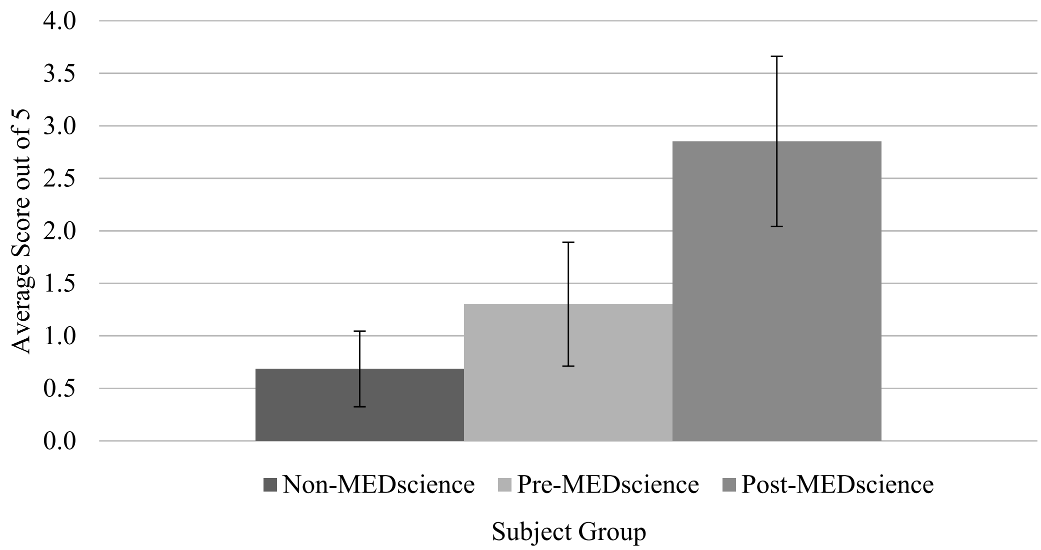


Figure 2. Average Score on MEDscience Test for Content across cohort groups



The purpose of this data was to look at effectiveness of the MEDscience program, which is evident in the 104.3% increase in summative score for Post-MEDscience students when compared to Pre-MEDscience students (Table 9). Also, note an unanticipated increase of 88.3% between Pre-MEDscience and Non-MEDscience students.

Table 9. Percent increase comparing average score of participant groups

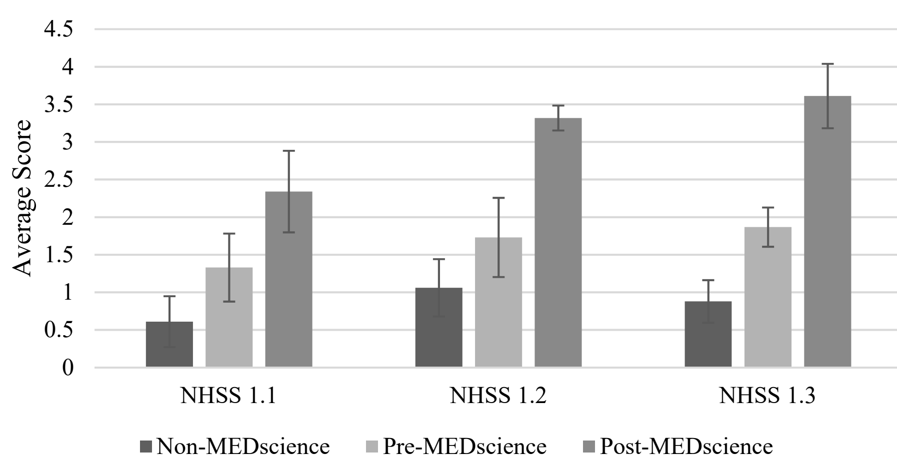
Participant Group Comparison	Percent Increase
% increase Comparing Pre-MEDscience to Post-MEDscience	104.3%
% increase Comparing Non-MEDscience to Post-MEDscience	284.6%
% difference between Non-MEDscience to Pre-MEDscience	88.3%

National Health Science Standards. The National Health Science Standards (*Appendix H*) were used as a benchmark to compare the expected level of understanding in health sciences with the actual level of understanding in graduating high school students in health science. Students who understand the topics listed in the NHSS would have more foundational knowledge that would lead to a higher health literacy, than those who do not know about topics in health science.

Standard 1 target different aspects of a student's academic foundation of human systems (Table 10) (National Health Science Standards, 2015). An increase was seen for all sections of Standard 1(Figure 3).

Table 10. Subcategories of NHS Standard 1: Academic Foundation	
1.1	Human Anatomy and Physiology
1.2	Diseases and Disorders
1.3	Medical Mathematics

Figure 3. Average score on NHS Standard 1 sub-standards on MEDscience Test for Content



With the focus on improvement through the implementation of the MEDscience program, it is worth noting that improvement was seen on all three sub-standards of NHSS Standard 1 (Table 11) between the Non-MEDscience cohort and Post-MEDscience cohort.

Table 11: Percent increase comparing average scores on NHS Standard 1			
Participant Group Comparison	NHSS 1.1	NHSS 1.2	NHSS 1.3
% increase from Pre-MEDscience to Post-MEDscience	76.1	99.6	97.0
% increase from Non-MEDscience to Post-MEDscience	283.6	231.9	325.4
% increase from Non-MEDscience and Pre-MEDscience	117.8	65.0	129.3

Figure 4 shows improvement for all remaining standards after the implementation of the MEDscience program. Percent increase for standards 2, 4, 8, 9, and 10 shown in Table 12, the highest percent increase between the Non-MEDscience and Post-MEDscience cohorts being in Standard 9 and 10, 394.1% and 424.2% respectfully.

Figure 4. Comparison of average scores on MEDscience Test for Content across NHS standard and cohort group

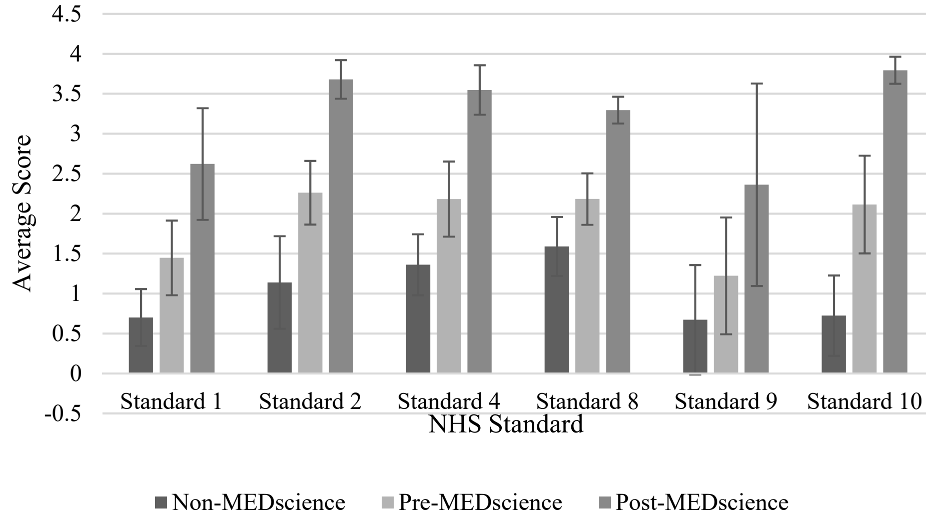
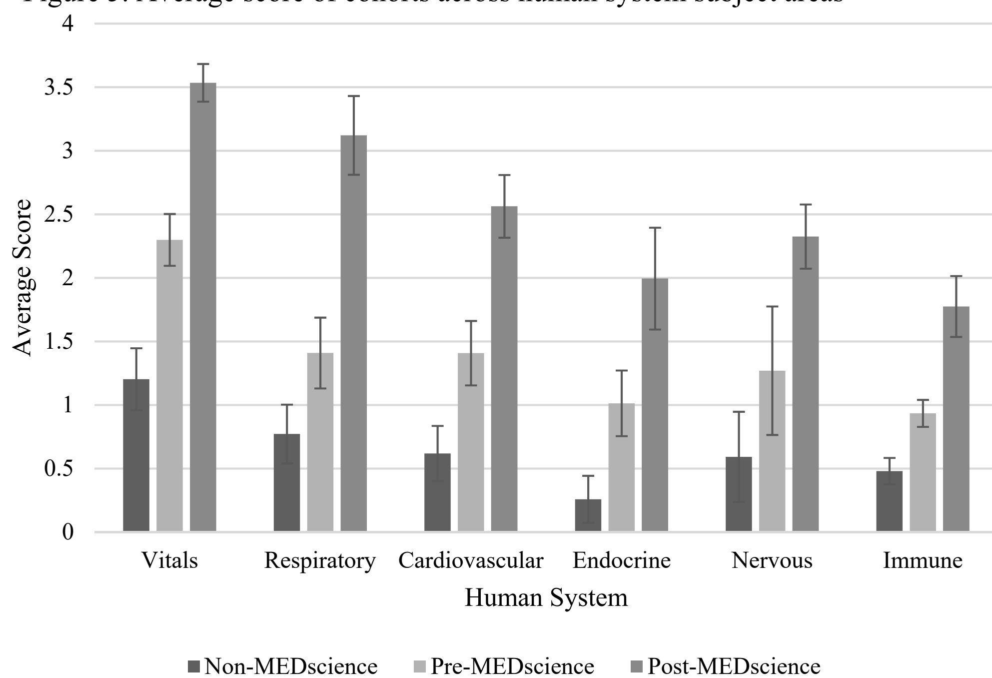


Table 12: Percent increase comparing average scores on remaining National Health Science Standards					
Participant Group Comparison	NHS Standard 2	NHS Standard 4	NHS Standard 8	NHS Standard 9	NHS Standard 10
% increase Comparing Pre-MEDscience to Post-MEDscience	62.7	66.1	53.2	100.6	79.5
% increase Comparing Post-MEDscience to Non-MEDscience	223.3	171.2	114.3	394.1	424.2
% difference between Pre-MEDscience and Non-MEDscience	98.7	63.8	38.7	141.4	192.1
*Not all NHS Standards are covered in the MEDscience curriculum. Only those standards covered are included in this study.					

Subject Matter. Comparison across subject matter was analyzed to compare body systems that were better understood by the study population after taking MEDscience with those that were not. Subjects such as vitals, respiratory and cardiovascular demonstrated the highest level of understanding after completing the MEDscience program (Figure 5). Subjects are displayed along the horizontal axis in the order in which they were taught, with a general trend downward from the start to the finish of the program (Figure 5).

Figure 5. Average score of cohorts across human system subject areas



T tests were run to determine significance between Pre-MEDscience and Post-MEDscience test scores, Non-MEDscience and Post-MEDscience, as well as Non-MEDscience and Pre-MEDscience scores across subject area (Table 13). For AIM I and measuring the effectiveness of the MEDscience program as an improvement to an individual's health literacy between students who have taken the program (Post-MEDscience) and those that have not (Non-MEDscience), we note the largest difference in scores being in the Vitals, Respiratory, and Cardiovascular subject areas. Over 250%

was noted for all subject areas when comparing Non-MEDscience and Post-MEDscience cohorts (Table 13).

Table 13. P Values and % increase for comparison between cohort groups across subject area				
		Pre-MEDscience to Post-MEDscience Comparison	Non-MEDscience to Post-MEDscience Comparison	Non-MEDscience to Pre-MEDscience Comparison
Vitals	P Value	1.14E-08	3.93E-24	3.93E-07
	% Increase	58.50	278.55	149.70
Respiratory	P Value	6.16E-12	1.58E-17	7.24E-05
	% Increase	121.5	304.3	114.9
Cardiovascular	P Value	2.63E-08	1.18E-13	0.0018
	% Increase	130.0	809.4	223.8
Endocrine	P Value	9.94E-07	1.95E-09	8.22E-07
	% Increase	120.4	1330.5	567.9
Nervous	P Value	0.0025	4.10E-05	0.0019
	% Increase	934.7	397.1	207.7
Immune	P Value	1.00E-05	5.07E-08	0.0965
	% Increase	98.3	350.3	113.9

Bloom's Taxonomy. Student success was compared by the type of question asked, according to Bloom's hierarchy model of cognitive domains (*Appendix I)*. Growth was seen in all categories after MEDscience implementation (Table 14). The most notable growth being in the "analyze" category (Table 14).

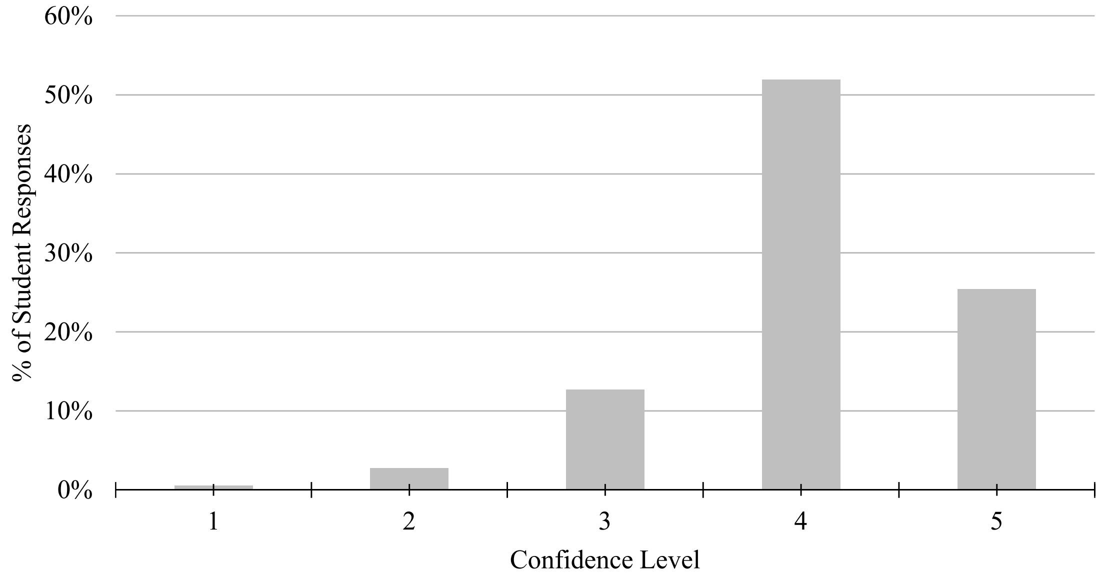
Table 14. Percent increase between cohort groups across different levels of Bloom's Cognitive Domains						
	Remember	Understand	Apply	Analyze	Evaluate	Create
Percent Increase comparing Pre-MEDscience to Post-MEDscience (%)	81.8	69.3	96.0	129.6	71.6	50.0
Percent Increase comparing Non-MEDscience to Post-MEDscience (%)	267.4	312.3	241.8	353.2	329.1	143.2

MEDscience, *The Experience* analysis. 89% Percent preferred the pedagogy and form of instruction in the MEDscience program compared to their typical high school courses. Of those 89%, students reported they preferred this form of learning for the following reasons (Table 15). Examples of responses included in the "other" category include: "it helps me apply what I learned in the classroom" and "so much better and more fun."

Table 15. Percentage of students that preferred MEDscience over classroom instruction due to the following categories	
More realistic	30%
More hands-on nature of the experience	33%
More engaging, interesting, and effective learning environment	31%
Other	6%

After the MEDscience session, 83% of students stated they were confident to very confident in understanding the material taught during the session (Figure 6).

Figure 6. Student self-reported confidence level in reference to the concepts they learned during HMS experiential session



AIM II. Comparative analysis of current health programs

Health education approach

Among the 12 school teachers surveyed, 58% taught at private schools and 42% taught in public schools. Among these schools, 58% had a specific health course and 42% did not, but the lack of specific health programs was shared between public and private schools (Table 16). Out of these explicit health programs, the only system that is covered 100% of the time is the reproductive system (Table 17) indicating the main goal of health programs being sex, or reproduction education.

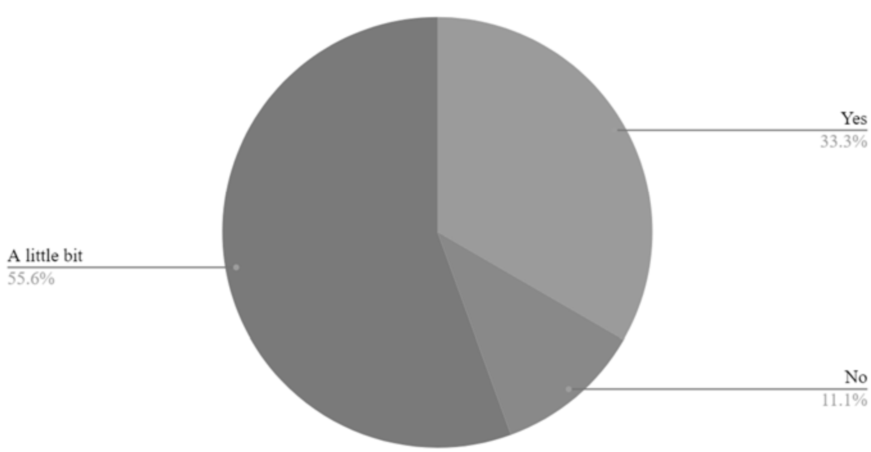
Table 16. Schools that have designated health programs

	Yes	No
Public	60%	40%
Private	57%	43%

Table 17. Frequency of systems covered in required high school health course	
System	% Occurrence
Reproductive	100%
Skeletal	67%
Muscular	67%
Respiratory	67%
Cardiovascular	67%
Nervous	50%
Endocrine	50%
Immune	50%
Excretory	50%
Digestive	50%
Integumentary	33%

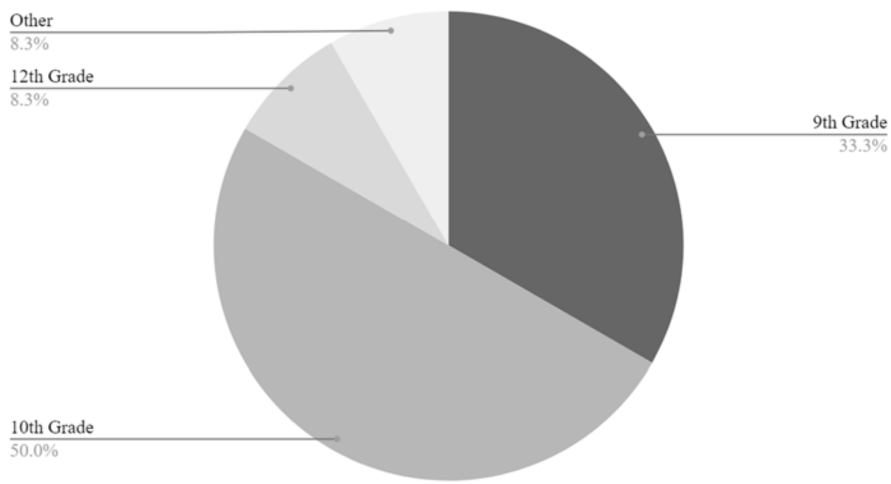
Of the health curriculums that covered human systems, 33% reported that they covered the systems in a diseased state, 67% reported the covered the systems in a diseased state a little bit, and 0% reported that they did not (Figure 7).

Figure 7. Percent of schools that cover human system in a diseased state



83% of the health education programs analyzed in this study ended by the 10th grade (Figure 8).

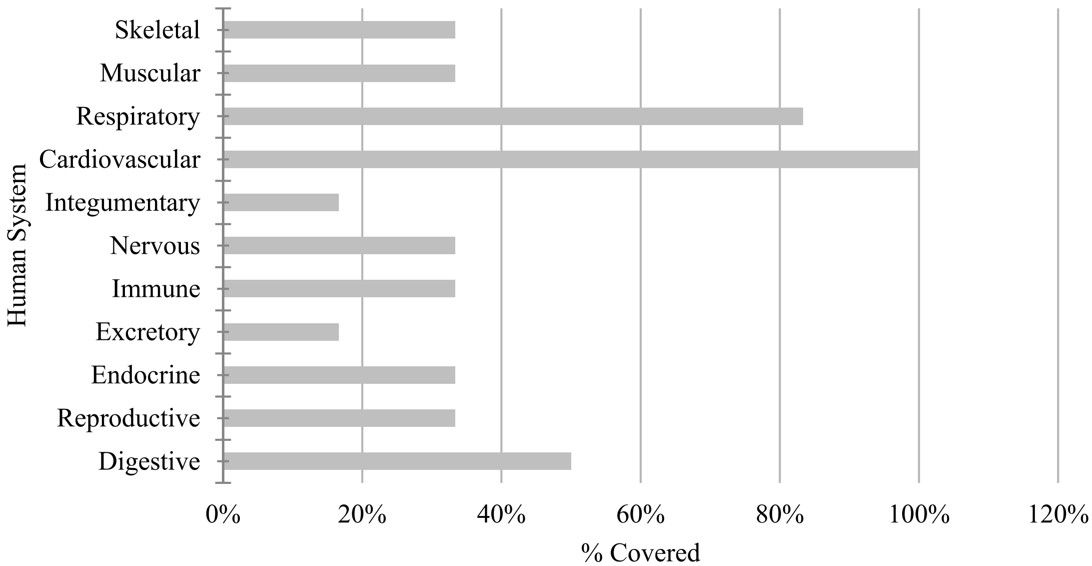
Figure 8. Grade at which explicit health education ends



Implicit health education through other courses

Health program aside, it is evident that many systems in both healthy and a diseased state may be covered in other science courses, therefore giving students health education implicitly. 75% of teachers stated health topics are covered in biology and anatomy and physiology courses at their school. The top two systems that were most likely to be covered in an additional required science course were the cardiovascular system and the respiratory system (Figure 9) with the remaining systems being covered in far fewer required courses.

Figure 9. Frequency human systems are covered implicitly in other required courses offered in high school



AIM III. Growth comparison of individual students in MEDscience programs across NHSS, and how it relates to participation

Full Case Study analysis

<u>MEDscience Test for Content analysis.</u> Student performance increased between Pre-MEDscience and Post-MEDscience cohorts 104.3% (Table 9). In an unpaired t-test, the p value of $2.98x10^{-10}$ indicates the groups are statistically significant at the 0.05 significance level (Table 8).

<u>Standard-Based analysis.</u> Student performance increased across all NHS standards, ranging from a 53% increase in NHSS standard 8 to a 100.6% increase in NHS standard 9 between Pre-MEDscience and Post-MEDscience cohorts (Table 12).

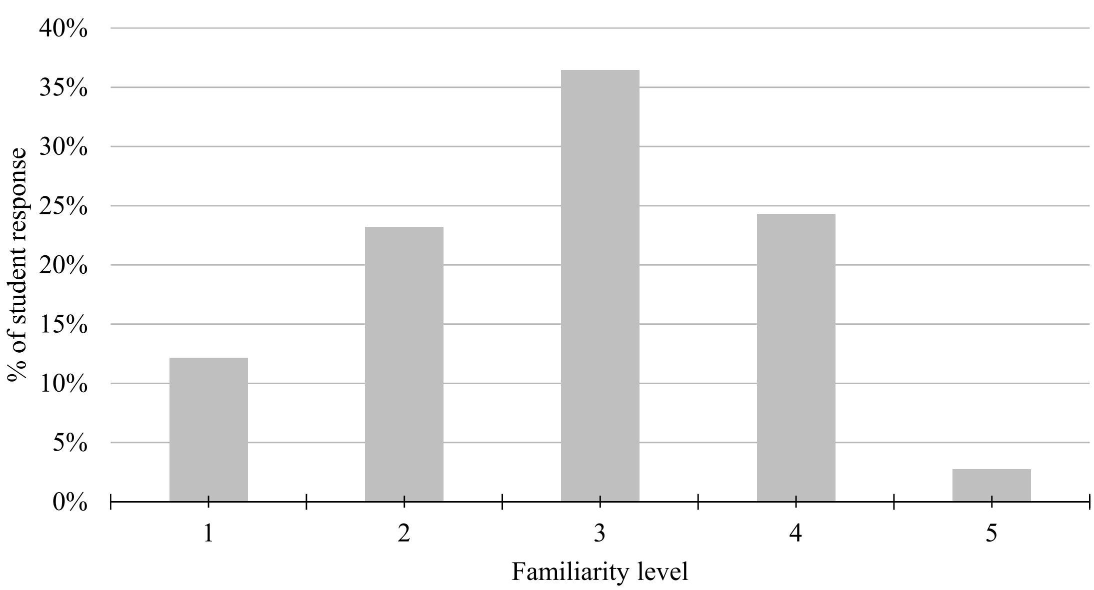
<u>Subject Area Analysis</u>. Student growth was seen across subject areas between Pre-MEDscience and Post-MEDscience cohorts (Figure 5), with the most significant growth

in the Vitals, Respiratory and Cardiovascular subject areas (Figure 5). The test statistic was calculated for all 6 subject areas, p values indicate the Pre-MEDscience and Post-MEDscience Test for Content scores were significantly different at a 0.05 confidence level (Table 13).

<u>MEDscience, *The Experience* Analysis.</u> Formative data was collected after each MEDscience session at Harvard, responses were analyzed to better understand student experience and how it relates to growth in health literacy before and after the MEDscience program.

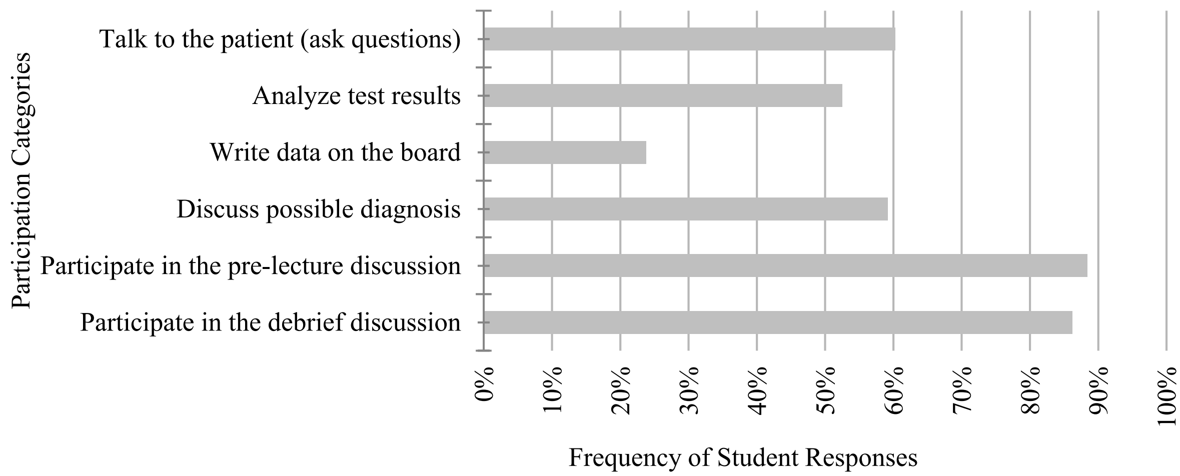
Prior to the lesson, 72% of students felt a range between completely unfamiliar and somewhat familiar (range of 1 to 3 on Figure 10). After the lesson, 83% of students stated they were confident to very confident in understanding the material taught during the session (Figure 10).

Figure 10. Student self-reported familiarity level to lesson topics prior to the HMS experiential session



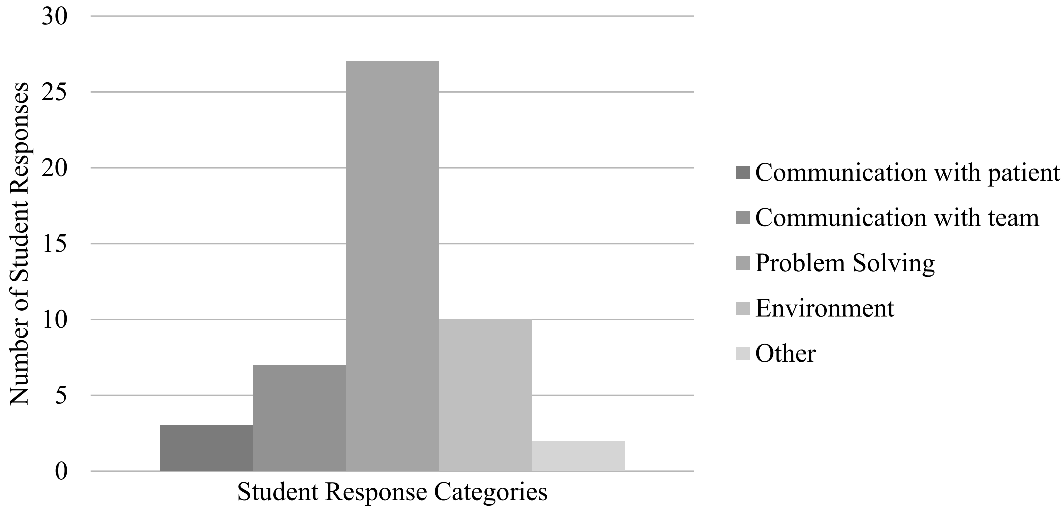
As for how students participated, students self-reported that they on average participated most during the pre-lecture discussion and the post-simulation debrief 89.4% and 87.2% respectfully, compared to during the simulation itself (Figure 11).

Figure 11. Student self-reported ways in which they participated



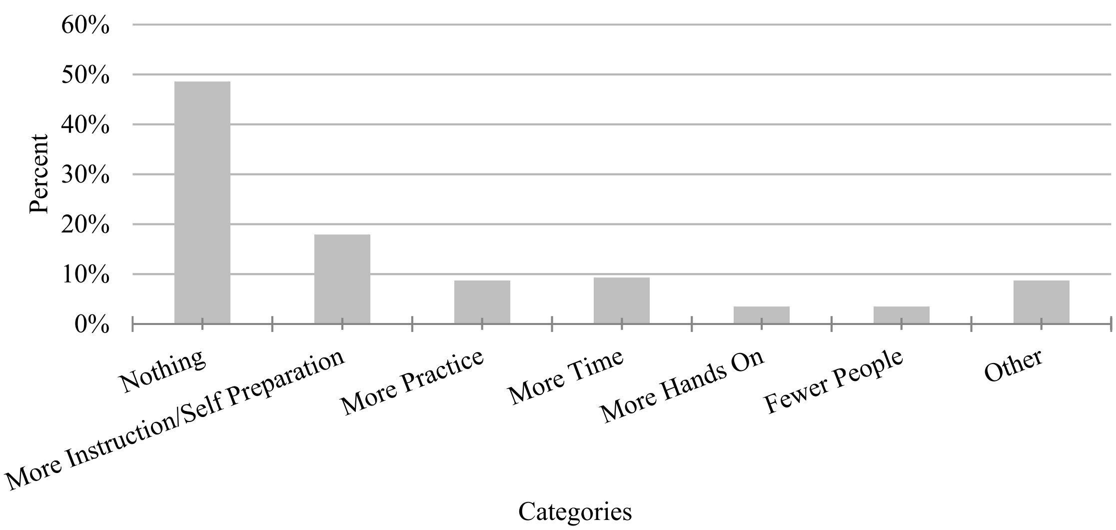
Participation can also reflect what was most challenging. The problem-solving aspect of the session was most challenging for most students (Figure 12). Fewer people reported that they participated in areas that require problem solving compared to areas that were discussion-based (Figure 11).

Figure 12. Student responses on what was most challenging during the HMS case-based experiential sessions



Looking forward in how to improve the program, 48.6% of students reported "nothing" and 17.9% of students reported either "more instruction" or "more (self) preparation" (Figure 13).

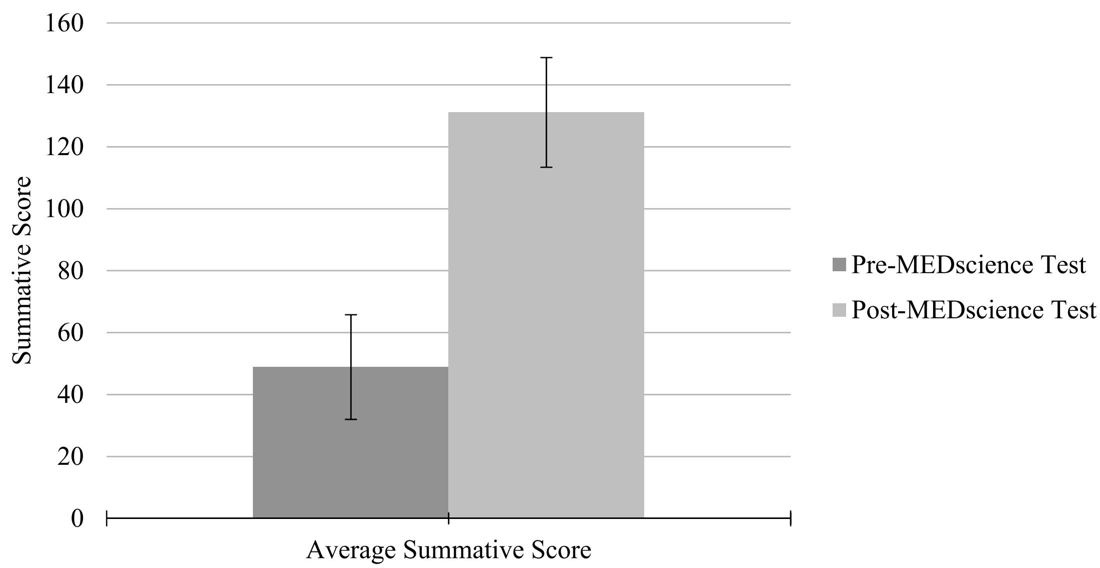
Figure 13. Frequency students reported how best to improve the MEDscience program



Pre-MEDscience to Post-MEDscience paired focus group

<u>MEDscience Test for Content analysis.</u> A matched paired t test was performed for those students in Trial 2 who identified themselves in both the Pre-MEDscience and Post-MEDscience Test for Content trials (n=9). There was a statistically significant difference between the two trials with a p value of 1.30x10-7 at the 0.05 significance level (Figure 14).

Figure 14. Paired comparison between Pre-MEDscience and Post-MEDscience students average summative score on the MEDscience Test for Content



<u>Participation Analysis.</u> Participation was identified as an indicator to Post-MEDscience test performance. A positive correlation was found between student's overall summative participation score and their Post-MEDscience Test for Content summative score (Table 18). % increase was measured for students who took the MEDscience Test for Content both before and after the program and is seen in Table 18.

Table 18. Overall summative participation score compared to Post-MEDscience Test for Content summative score									
	S7*	S12*	S13*	S11*	S2*	S6*	S5*	S1*	S8*
Overall Summative Participation Score	116	113	113	94	92	89	88	81	74
Post-MEDscience MEDscience Test for Content Summative score	138	163	145	140	119	131	121	120	103
*S(n) is the student identifier									

Chapter IV

Discussion

The purpose of this study was to gain an understanding of the level of health literacy in graduating high school students, with the reason being high school may be the last opportunity for many of them to learn topics associated with the human body and proper health. Health literacy is a growing concern and can have a major impact on a person's life-long health decisions and quality of life. It is clear education in health-related topics is necessary, but this leads to the following questions: What is an effective way of teaching health-related topics? What do the current programs being taught to our youth include? And what is the most effective pedagogy for teaching these topics? In this discussion, we aim to address these questions, but also point out additional considerations when building health-related programs that we found to influence this study, as well as discuss the limitations to this study and suggestions for future research.

AIM I: Effectiveness of the program MEDscience

MEDscience Test for Content Analysis

When comparing the scores on the MEDscience test for those individuals who had completed the MEDscience program both to those that had yet to complete it (Pre-MEDscience) and those who did not sign up (Non-MEDscience), there was a significant difference in the overall summative scores for the test (Figure 1-2). P values were calculated between these three different cohorts, and all were deemed significant, meaning we reject the null hypothesis, and state there is a statistical difference in performance between these three groups. The statistical difference between the Pre-MEDscience and Post-MEDscience groups is evidence that the treatment, being the MEDscience program, did have a significant effect on the student's knowledge and understanding in health literacy topics, evidence by the 104.3% increase on the MEDscience Test for Content. An interesting discovery in this test is the significant difference between Pre-MEDscience and Non-MEDscience students (Table 8), with the Pre-MEDscience students having a significantly greater knowledge of the health literacy topics even prior to taking the MEDscience program. We believe this is a product of the self-selection nature of the program as it stands in its current existence. It is not a required course. Therefore, those students who self-selected for MEDscience (Pre-MEDscience) had a prior knowledge, perhaps due to implicit education of these topics in other courses or simply due to interest in the subject area, that was greater than those who choose not to take MEDscience (Non-MEDscience cohort). This prior knowledge was great enough that there was a significant difference between these two cohorts, and therefore the idea that all students start with the same baseline information about health science from the current required health curriculum is rejected (Table 8). Because of this discrepancy in student knowledge among high school students who have not or have yet to take the course, it gives reasoning to support the recommendation that all students be required to complete a program like MEDscience, to ensure all students graduate high school with a greater level of health literacy.

National Health Standards Comparison. Because the MEDscience Test for Content is not a standardized test, each question was paired with the appropriate National Health Science Standard(s)(NHSS) that it addresses to validate the reasoning behind why success in the areas covered on the test are so important. NHSS are designed to provide a level of expectation for graduated high school students and potential health industry students (National Health Science Standards, 2015). A large part of being health literate is having the ability to communicate and understand information being relayed by your health care professional. By targeting these standards in the MEDscience Test for Content, we can strive to have a higher health literacy. As mentioned previously, NHS Standard 1 is the "Academic Foundation" standard, which targets the ability to "understand human anatomy, physiology, common diseases and disorders, and medical math principles" (National Health Science Standards, 2015). This standard was covered over a large majority of the MEDscience Test for Content, as it defines a large part of having health literacy. For all three sub standards, anatomy (1.1), disease (1.2), and medical math (1.3) there was an increase in student performance between those individuals who did not sign up for the program and those that did and had completed the MEDscience program (Figure 3). Two areas that are arguably the most important when related to health literacy, disease and medical math, showed a 231.9% and 325.4% increase respectively (Table 11). When thinking about how an individual might use information from the MEDscience program to improve their health literacy, the anatomy is an important foundation, but why and how to manage the body in its diseased state is what will be most applicable to their everyday lives, when the individual might be battling with managing a disease or disorder of their own or a loved one. In addition, medical math, or the ability to analyze and understand mathematical conversions as they relate to health care (National Health Science Standards, 2015) is extremely important. Many of our vital signs are now measurable either at home or the local pharmacy. This accessibility to information about our own bodies is empowering and can be largely beneficial to preventative health care. The limiting factor, or issue being that the individual must be able to properly interpret the data they receive from the measurable tests. Heart rate, blood pressure, and temperature are all extremely easy to measure outside of the doctor's office, but without the knowledge of what 120/80 mmHg means, or how to convert temperature in Celsius to Fahrenheit, individuals can be held back from properly managing their own care, and therefore are at a lower health literacy. The 325.4% increase in NHSS 1.3 (Table 12) from the MEDscience program is important for this reason. One may be alarmed by such a high percent increase for these standards, but it is important to take into consideration that for some of these standards, the general knowledge of the population (Non-MEDscience cohort) is so low, that any increase has a drastic change in the data. We will see this extreme variance intermittently throughout the study.

All other National Health Science Standards also showed an increase in the essential understandings outlined in NHSS after having completed the MEDscience program, indicating the MEDscience program is effective in improving many aspects of health literacy, not simply human system knowledge. Standard 2 addressed the communication required in health care. Students after having taken MEDscience showed a 223.3% increase on average scores compared to Non-MEDscience students in their ability to communicate effectively (Table 12), which included but was not limited to using medical terminology, understanding objective and subjective information, communicating without bias or attitude, and using thoughtful speaking and active listening skills. Proficiency is required in these skills by our medical professionals, but in order to accurately communicate with the professionals about medical care, it is important we as individuals also hold a level of understanding in proper communication. This ability correlates with health literacy, therefore the MEDscience program was the cause for the 223.3% increase in health literacy communication.

A large portion of a person's health literacy is focused on their knowledge of proper preventative care and acknowledgement of risk factors associated with common diseases that plague our society, and the MEDscience showed evidence of improving this knowledge. Standard 9 addressed best practices around health maintenance. After completing the MEDscience program, students demonstrated a 394.1% increase between the Non-MEDscience and Post-MEDscience average scores (Table 12). With that being said, note that the average score for the Post-MEDscience students does not reach 3 (out of 5) for Standard 9. Therefore, even with this great improvement, students are still below average, as defined in the scoring rubric *(Appendix E)*, in their understanding of proper health maintenance. Given that health maintenance and preventative health care are essential components to decreasing a family's potential long-term health care costs (Rasu et al., 2015), this should be a focus for our health education programs in the future.

Standard 10 addressed the technical skills required for all career specialties, such as recording and understanding normal ranges of vital signs and becoming CPR and first aid certified. This standard is important to health literacy, because not only should the graduating students be able to help themselves, they should also be able to help others. The 424.2% increase between Non-MEDscience and Pose-MEDscience students' ability of to properly describe the technical skills required to appropriately help people in need (Table 12). The average score was 3.8 (Figure 4) where a score of 4 indicates an "above average" understanding of the concepts, identifying this standard as being the one that demonstrated the greatest different between Non-MEDscience and Post-MEDscience cohorts. The drastic increase in this standard is an important indicator of improved health literacy, because when we think about the advantages to improving health literacy, it is not solely to empower individuals to make better health decisions for themselves, it is also about having the ability to help loved ones or other members of our society.

Standard 4 addressed the employability skills of the individual for a health care profession. Skills such as understanding chain of command, teamwork, support services, credential requirements, and other aspects of an employee's portfolio were identified. The purpose of standard 4 in this study was not to identify the student's ability to improve these skills for going into a health care profession, but to gain these skills to improve an individual's ability to communicate with health care professionals and properly use our healthcare system. A 171.2% increase in standard 4 (Table 12) between Non-MEDscience and Post-MEDscience students suggests that students who have completed the MEDscience program have more of the skills required to effectively communicate with healthcare professionals, and therefore a higher health literacy.

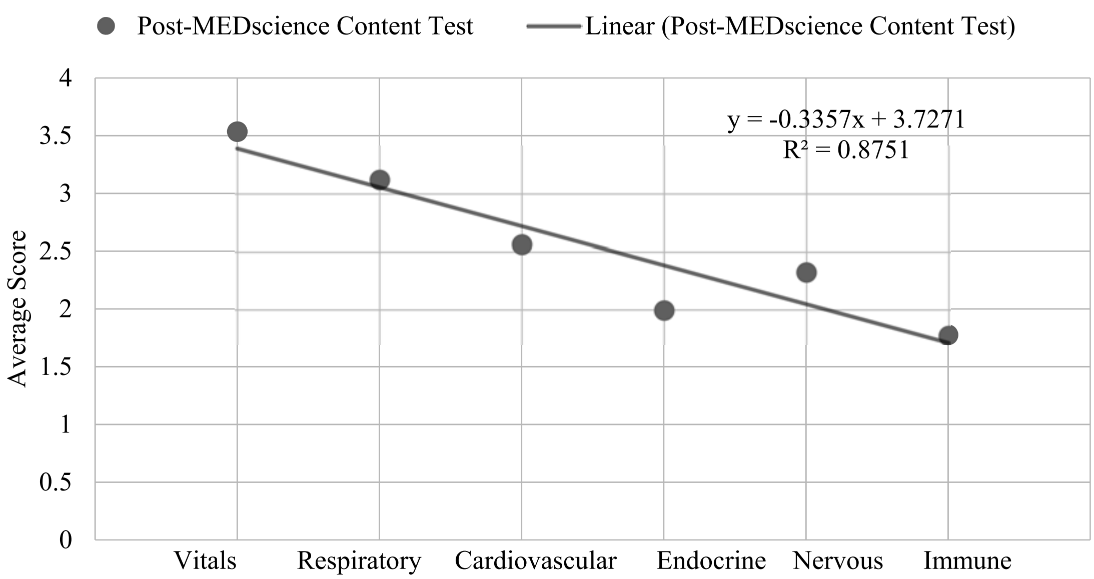
Lastly, standard 8 targets the ability for individuals to work in a team, specifically targeting the characteristics of effective teams as well as applying effective team managing skills in conflict (National Health Science Standard, 2015). This standard was targeted in this study because a lot of disease management and health care decisions could involve overcoming conflict between family members or healthcare professionals. Students demonstrated a 114.3% increase in knowledge of these skills after having taken the course, compared to those who did not sign up (Table 12). This indicates the

MEDscience program makes individuals more equipped to navigate discussions, disagreements, and emotions around proper health care, which is vital when a patient is trying to make an informed decision about their own health care or treatment regimen.

Subject Matter Comparison. After analysis of the MEDscience Test for Content, it became clear students performed more strongly in some human subject areas compared to others. As seen in Figure 5, the three highest scoring subjects were vitals, the respiratory system, and the cardiovascular system. In addition, these three subjects scored the lowest p value 3.93×10^{-24}, 1.58×10^{-17}, and 1.18×10^{-13} respectfully (Table 13), when Non-MEDscience and Pre-MEDscience scores were compared, meaning the Post-MEDscience data was the most statistically different from the Non-MEDscience data for these three subjects. There are multiple reasons one would argue why these subjects scored higher and were more significant than the others. The first being that these three subjects are "easier" or more intuitive compared to the others. For example, if asked to name a structure in the respiratory system, the vast majority of individuals may be able to say "lungs" without any prior instruction. Similarly, with the heart and the cardiovascular system, and temperature as a vital sign. However, arguably far fewer individuals would be able to name the pancreas as an endocrine gland or even the skin as an organ in the immune system. The endocrine and immune systems are far less intuitive. In addition, inexplicit learning from previous courses inadvertently plays a role here. Vitals, the respiratory, and the cardiovascular systems are more approachable systems to teach at a younger age, and therefore there is a higher potential that they were taught to some degree in a previous course, giving individuals implicit prior knowledge of the systems before entering the MEDscience program. The cardiovascular and respiratory system were covered 100% and 83% of the time respectively in other required science courses, indication the likelihood that these subjects have a higher foundation of knowledge compared to others upon entering the MEDscience program.

Another trend worth noting is the decline in performance over the course of the program. A linear regression analysis was completed on the relationship between performance and the order in which the subjects were taught (Figure 15). An R2 value of 0.875 suggests that the order in which the subjects are taught is a significant predictor for how the students will perform.

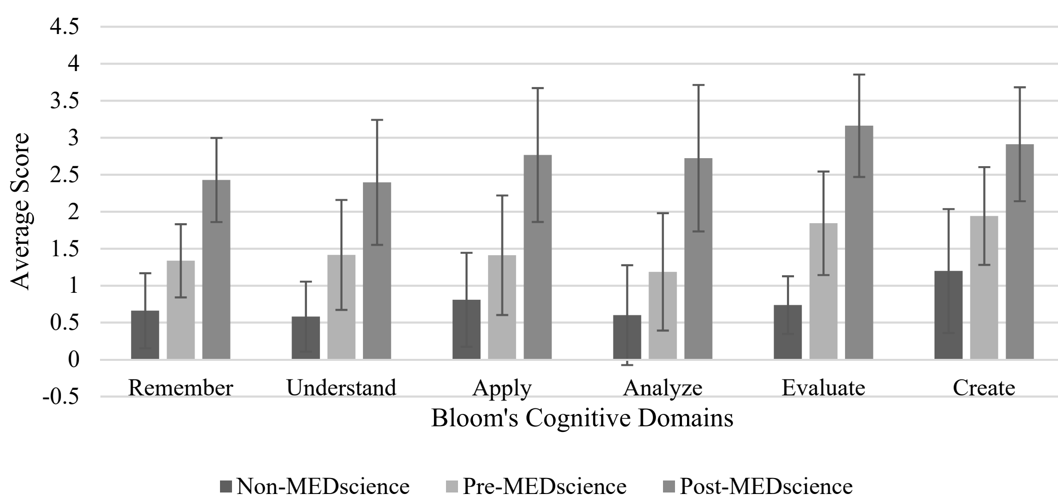
Figure 15. Average Score of Post-MEDscience students across subject area in the order in which they were taught



Other factors that could explain this data are that more relatable, attainable, subjects are purposefully put towards the forefront of the MEDscience program, to give students an opportunity to acclimate to the environment and gain confidence in the experiential style of learning. Another factor to consider is test fatigue. The order of the questions on the MEDscience Test for Content align with the order in which the subjects are taught in the program. It is possible students scored more poorly on the immune system questions compared to the respiratory system questions simply because they were at the end of the test. Test fatigue is a serious limitation to this area of the study, and accommodations that could be made to mitigate this in future studies is recommended.

Bloom's Taxonomy. Bloom's taxonomy was used to categorize questions and their responses based on the level of hierarchical cognitive ability to accurately answer the question. All six levels of hierarchical thinking were addressed in this study, ranging from the lower levels which required students to remember, to the highest level which required students to create; meaning produce new, original ideas based off a question (Bloom, 1956). An increase was seen in all levels of taxonomy between Non-MEDscience and Post-MEDscience students (Figure 16), the largest being the analyze level at a 353.2% increase (Table 14).

Figure 16. MEDscience Test for Content questions grouped according to Bloom's Cognitive Domains



This increase is evidence of the types of thinking skills that are harnessed, practiced, and showcased through this program. Each MEDscience session requires students to thoroughly and repeatedly analyze both subjective and objective data in order to problem solve and ultimately diagnose the patient. This technique is practice in class through written case studies, where students are presented with a problem, a series of data, and asked to properly analyze the data and come to a conclusion. The improvement in all levels of Bloom's Taxonomy is evidence of an increased health literacy. To be health literate, one must be able to remember, understand, analyze, and evaluate health situations, medication regimens and recommendations by the physicians to get the most out of their health care and have the best chance for either health improvement or a heightened quality of life.

<u>MEDscience, *The Experience* analysis.</u> In addition to the MEDscience Test for Content, a formative assessment titled MEDscience, *The Experience* was analyzed, and data was used to demonstrate the effectiveness of the MEDscience program as a method of improving health literacy. When asked if students preferred the pedagogy instilled in MEDscience over a typical high school course, 89% of students said "yes." The reasoning being that the MEDscience program was more realistic, more hands on, more engaging, and more interactive leading to a more effective learning environment (Table 15). If students are engaged and enjoying what they are learning, they will be more likely to retain that experience (Alioon & Delialioglu, 2017) and use the information they learned in a future health-related setting, therefore improving their health literacy. In addition to having the content knowledge, improving confidence and comfort with the health-related topics will also improve health literacy. After the MEDscience program,

83% of students responded that they were confident to very confident with the subject material (Figure 6). This confidence in health-related topics will make the individual more likely to speak up in a doctors' office, ask questions, and show initiative for their own health; all characteristics of a higher level of health literacy.

AIM II: Comparative analysis of current health programs in the Boston area.

Health Education Approach

By comparing the different implicit and explicit approaches to health education, we can make recommendations on how better to serve our students in this field and equip them with the proper knowledge to become more health literate than they would have otherwise. The first variable to tease out are the subject areas, or human systems that are being explicitly taught in a health program that is required for graduation. If the goals is to improve health literacy in graduating high school students, one cannot assume all students would choose to take a health program if given that choice. Therefore, to better control and improve the level of health literacy of all graduating students, the course in which we do so must be required. The first surprising piece of evidence is the presence of schools, both public and private, 40% and 43% respectfully, that still do not have any form of specific, required health education program (Table 16). Students in these schools must rely on a general science or biology class to gain all their education on topics typically covered in health education such as safe sex, human systems, diseases, disease prevention, healthy relationships, drugs and alcohol, sex trafficking, and many others. Keep in mind, the biology and general science classes have other frameworks and goals to reach in terms of content as well. There simply is not enough time over the course of a school year, or even two, to try and fit all the important topics related to health education as bits and pieces of other courses. Therefore, the first recommendation is to have a space for student's sole focus to be learning many of the topics mentioned above is crucial to the improvement of our graduating high school student's level of health literacy.

In reference to this study, where the focus is not on sex education but instead on health education as it relates to human systems in a diseased state, it was important to look at other systems that were covered in the health programs. Aside from the reproductive system, which was covered 100% of the time, no other system was covered in every instance (Table 17). This indicates that the trend of most health education programs focuses on sex education, or the reproductive system. The systems that were covered the most frequently were the muscular, skeletal, cardiovascular, and respiratory system, all covered 67% of the time. After that, some of the arguably more challenging systems such as the endocrine, nervous, and immune systems were only covered 50% of the time (Table 17). This is a clue that some students may be more knowledgeable in some systems compared to others based on what was covered in their health education course. Given this data, in this study, we could argue that all student cohorts should score higher on average on questions related to the respiratory and cardiovascular system compared to the endocrine, nervous, and immune systems due to the implicit learning they may have received in a health education course. Health literacy is dependent on the additional discussion of human systems in a diseased state. 33% of teachers reported the disease state of the systems was covered in the health education course, 67% reported the diseased state was covered a little bit in the course, and 0% reported the systems were not covered in a disease state (Figure 7). This is important because it demonstrates that curriculum prioritizes discussion of systems in a diseased state and will only lead to improving our current state of health literacy.

Another consideration, besides content, when implementing a health education approach is the frequency that the course meets and the length of the program. Of the programs surveyed, 83% of them finished by the 10th grade (Figure 8) and ranged from meeting 2 to 4 times per week. Many teachers commented that some students choose to continue their health education in courses like anatomy and physiology, but those are not required for graduation. Ultimately, if students are finishing their health education by the 10th grade, perhaps there is time and opportunity to implement a required program like MEDscience that targets systems in a healthy and diseased state more extensively, in a new a different style of learning that lends better to the older age group. Skills such as analyzing and problem solving require a higher level of cognitive ability (Bloom, 1956) and therefore may be more successful in an older student population.

Implicit health education of human systems

A health course is not the only place a student can gain knowledge about the human systems in both a healthy and diseased state, and therefore we must consider the implicit health education students are receiving in other courses, and how that may impact health literacy. In fact, human systems are covered in optional courses, such as anatomy and physiology, MEDscience and AP Biology, with a small percentage of systems (cardiovascular and respiratory) generally covered in a standard biology or science course (Figure 9) that is required for graduation. Reasoning behind why the cardiovascular and respiratory systems are covered more frequently than all others includes the approachable and relatable nature of the system, as well as the connection between this system and other general biology topics such as cells, cell transport, and cellular respiration. Once again, due to the emphasis on the cardiovascular and respiratory systems in other required science courses, we can infer that students may have a higher understanding of health literacy concepts surrounding the respiratory and cardiovascular systems due to indirect education of these systems in other science courses.

AIM III: Growth comparison of individual students in MEDscience programs across NHSS, and how it relates to participation

Full Case Study

MEDscience Test for Content Analysis. Prior to analyzing the smaller, paired cohort, a fully-study analysis was done to compare the Pre-MEDscience and Post-MEDscience cohorts. As seen in Figure 1, in an unpaired t test there was a statistically significant difference between the summative scores with a p value of 2.98×10^{-10} at a level of 0.05 significance. These cohorts were considered unpaired at this point because not all Pre-MEDscience students became Post-MEDscience students and scores were not tracked by student for all data entries. A paired comparison of a smaller cohort is seen below. By comparing student data directly before and after taking the program, the data suggests the semester-long MEDscience program is an effective tool for improving student's health literacy.

Standard-Based Analysis. Performance on the MEDscience Test for Content increased across all NHSS standards after MEDscience students completed the program. The most notable improvement was in NHSS standard 9, with a 100.6% increase between Pre-MEDscience and Post-MEDscience cohorts (Table 12). The essential knowledges outlined in Standard 9 are centered around health maintenance, promoting healthy behavior, and an understanding of disease prevention. Given this was the largest increase between Pre-MEDscience and Post-MEDscience students, one could argue health maintenance is one of the largest takeaways from the program itself, or most influential aspects of the program, and therefore what students remember. Health maintenance and preventative actions are a large part of being health literate, therefore an increase in student's performance on NHSS standard 9 questions is an indicator that those students in MEDscience have a higher health literacy than they did prior to taking the course.

Subject-based analysis. To identify areas that were more challenging for students enrolled in the MEDscience program, we looked at the improvement between the Pre-MEDscience and Post-MEDscience data across all subject areas. Similarly, to what was seen in AIM one, we see the most significant difference (Table 13) in the Vitals, Respiratory and Cardiovascular subject areas (Figure 5). P values calculated indicate a significant difference for all subject areas, the vitals, respiratory and cardiovascular systems having a greater difference than the endocrine, nervous and immune subject areas. This evidence indicates the endocrine, nervous, and immune systems are potentially more difficult for students to understand and apply their learning compared to the vitals, respiratory, and cardiovascular subject areas. The vitals subject area showed the lowest percent increase from Pre-MEDscience to Post-MEDscience, indicating there was a higher level of proficiency in this area due to background knowledge, perhaps acquired from other courses. The level of familiarity to topic prior to the session at

Harvard, measured by the formative assessment, MEDscience: The Experience, showed no correlation to student performance on MEDscience Test for Content.

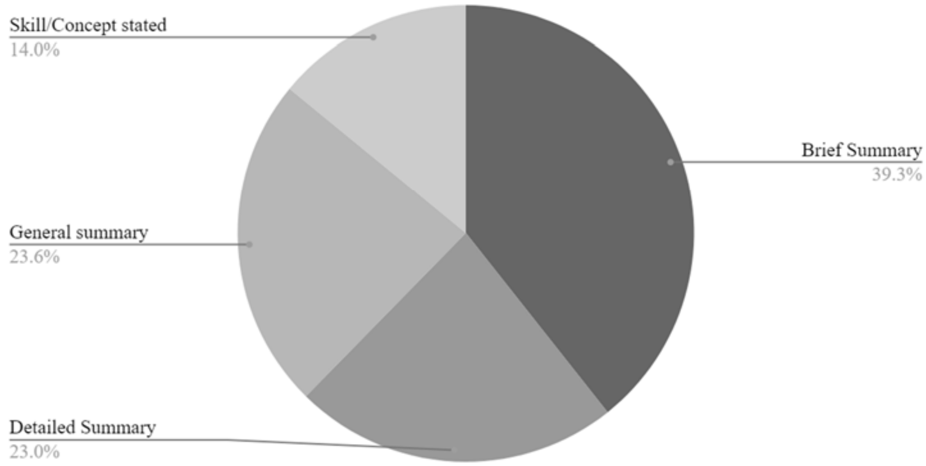
MEDscience, *The Experience* analysis. When measuring level of participation in students in the MEDscience experience, there were many ways in which students could participate (Figure 11). More students self-reported that they participated in the pre-lecture and post-session debrief compared to the other categories. Both moments in the session are ones where students are sitting as a large group, listening, answering questions, and having a discussion with the MEDscience professionals, either about what they have learned recently (pre-lecture discussion), or what the experienced in the session and how they feel they performed (post-session debrief). Both moments are ones where students are not communicating directly with the patient or with each other, instead the moments are more similar to what the students might experience in a typical class at school. Because students are more comfortable and familiar with this style of instruction, it makes sense they would feel they participated more at this time. Similarly, students responded overwhelmingly the most challenging aspect of the case-based session was the problem-solving component (Figure 12). Areas that involve problem solving scored lower in self-reported participation. This is evidence that the more challenging aspects of a program lend to having lower participation, which is in line with an observation by the teachers that many students were intimidated or are averse to things that seemed difficult. The exception to this in the data is the participation category that involved writing subjective and objective data on the board. The logistical constraints of this activity allowed a very limited number of participants per session (approximately two) to be able to write on the board, so naturally this category will score the lowest (Figure 11).

Another interesting point that was discovered in this data as it relates to student growth, was in the formative assessment, where students were asked to address in what ways they could understand the material more thoroughly, essentially, what ways they could improve their growth in health literacy through this program. Aside from the 48.6% that responded “nothing, which is a tribute to the success of the program, 17.9% of student responses stated they would benefit from more instruction and self-preparation (Figure 13). The in-class instruction and self-preparation are more similar to the more traditional model of a classroom. Thus, suggesting students benefit most from a bridge or collaboration between the hands-on, experiential sessions at MEDscience and more traditional learning in the classroom.

Lastly, data from the formative assessment MEDscience: The Experience measured the student’s ability to recall and describe the main objective of the MEDscience experiential session and summarize what they learned. 23.4% of student responses were able to provide a general summary, 23.4% of responses included a detailed summary, and 39.4% provided a brief summary of the experience (Figure 17).

Therefore, most students were able to recount, to some level, what they learned and experienced during the session, largely in part, due to their level of engagement.

Figure 17. Student's ability to describe the main objective and summarize what they learned during the MEDscience session



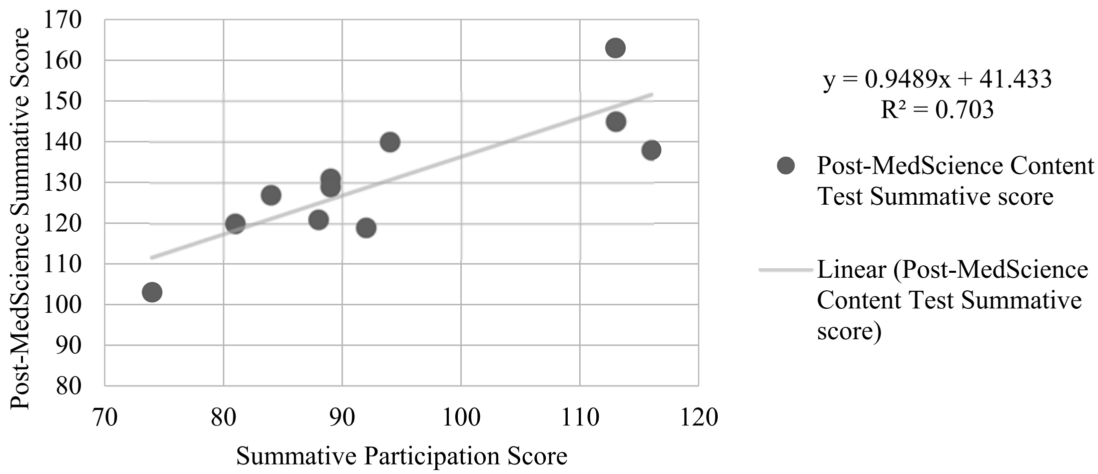
Pre-MEDscience to Post-MEDscience paired focus group

The small cohort of students who provided both Pre-MEDscience and Post-MEDscience data (n=9) which allowed us to track individual growth were the primary discussion in this AIM. A matched paired t test was performed and there was a statistically significant difference between the two trials with a p value of 1.30x10-7 at the 0.05 significance level (Figure 14). Therefore, the null hypothesis, being that the MEDscience program has no change on student performance on the MEDscience Test for Content was rejected.

<u>Participation Analysis.</u> Trial two included a participation analysis of individual students and compared it to the student's growth in the MEDscience Test for Content. A linear model was fit to the data relating participation and score on MEDscience Test for Content. The slope estimate was 0.949 (Figure 18) and was significantly different from 0, with a p value of 0.00126 at a significance level of 0.05. This indicates for every one-

point increase in participation, we expect the summative score on the MEDscience Test for Content to increase by 0.95 points (Figure 18).

Figure 18. Student participation as it compares to Post-MEDscience Test for Content summative score



To explain this data, we must think about what it means to participate. Participation was measured using the Participation Rubric (*Appendix C*), and covered many types of participation, including verbal and nonverbal communication with peers, professionals, and the "patient," as well as problem solving and the use of medical terminology. Self-reported participation can also be observed in Figure 13. Fundamentally, for all types of participation, a certain level of engagement in the activity is required, and arguably the more a student is engaged and participating in an activity, the more they are learning from it and the more likely they can recall it in the future.

Conclusion

Evidence from this study has provided us with important information about topics students learn in high school as it relates to health literacy, how programs vary among schools, and approaches that are effective to teaching health literacy-related topics. Students were evaluated, and the MEDscience program, developed by Harvard Medical School, was successful in significantly improving the health literacy of high school students, and therefore is an effective tool for schools to implement. Implementation of health education programs that target improving health literacy is imperative, as it was also found here that programs, when required, vary drastically across schools, indicating the baseline level of health literacy for all graduating students is drastically inconsistent. This inconsistency leads to many young adults becoming adults, with families, and still having a basic, or below basic level of health literacy as defined by Kutner et al., 2013. Low health literacy leads to increased healthcare expenditures (Rasu et al., 2015), and therefore this lack of education is costing our society large amounts of money.

Finally, when looking at health literacy and what elements of a program are most effective, we concluded that those students who participated more frequently had a higher level of health literacy, and therefore a program that cultivates the participation aspect of student experience, one that pushes students to think critically, create dialogue, and communicate with their peers, could lead to higher levels of understanding in health literacy. In our analysis of the MEDscience program, participation was found an indicator of higher health literacy scores.

Recommendations

The pedagogy behind the MEDscience program as a form of health education and improving health literacy is one that should be taken into consideration by schools looking to rebuild their health program. Not all schools will have the funds or access to all aspects of the MEDscience program, however aspects of the program (critical thinking, experiential learning, hands-on approaches, communication, etc.) as well as the way human systems are covered in the program could be adaptable to other school programs. These aspects of the program are covered in certain areas of the three domains of the Next Generation Science Standards *(Appendix J)* (NGSS Lead States, 2013), and therefore have already been determined important features to 21st century science learning. The specific areas of each domain have been pulled out of the standards *(Appendix J)* and listed below in Table 19.

Table 19. Next Generation Science Standards* that apply to the MEDscience program	
Disciplinary Core Ideas:	
HS-LS-2	Hierarchical organization of interacting systems that provide specific functions
HS-LS1-3	Feedback Mechanisms
Science and Engineering Practices	
Asking questions and defining problems	
Analyzing and interpreting data	
Using mathematics and computational thinking	
Constructing explanations and designing solutions	
Engaging in arguments for evidence	
Obtaining, evaluating, and communication information	
Cross-Cutting Concepts	

4. Systems and system models
5. Structure and function
6. Stability and change
*this table is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards were involved in the production of this product, and do not endorse it.

Examples of the evaluation of disciplinary core ideas and cross-cutting concepts are in the MEDscience Test for Content (*Appendix A*), whereas the science and engineering practices are seen in both the MEDscience, *The Experience* (*Appendix D*) formative assessment as well as the Participation Rubric (*Appendix C*).

In addition, local collaboration between healthcare professionals and teachers could enhance or aid in implementation of aspects of the MEDscience curriculum. Experiential, hands-on learning, and problem-solving in a diseased-based anatomy and physiology curriculum has proven effective in improving student's health literacy. We recommend MEDscience or a program similar be implemented and required for the upperclassman, after they have completed sex education and prior to graduation. Lastly, as we build these programs, we must be mindful of the current healthcare situation and prevalent health issues that plague our society, so that the curriculum stays relevant to the graduating students, to improve their health literacy and realistically prepare them for a health situation they may encounter in their future.

Another approach that could be beneficial to improving health literacy without implementing a MEDscience program would be to revamp the current required life science courses (Biology), to include the topics and elements covered in MEDscience. Introductory Biology often varies greatly by school, but if all biology programs implemented features of state-mandated health education frameworks, in a way that promoted more participation, communication, and hands-on learning, than improving health literacy would not be left solely for health education classes. Instead, it would be more integrated into many aspects of the high school experience and giving more opportunity for students to improve their health literacy.

Limitations

As mentioned previously, one of the most significant limitations to this study was the sample size and limited sample pools of the data. For this study, all students attended the same school. A more comprehensive analysis would include that of students from other schools taking the same MEDscience course. Part of the limitation there, however, is that the MEDscience program is young, and due to logistical and scheduling constraints, the amount of time spent on the material at school compared to at Harvard Medical School differs across schools. The consistent thread among the MEDscience programs are the sessions at Harvard, which met once per week.

AIM II would strengthen greatly from a larger sample size, painting a much clearer picture on where our society current falls in terms of following through with the mandated health education curriculum and specifically what human system topics are covered in the curriculum. To optimize the analysis of AIM II, having MEDscience Test for Content student data from the participating schools would allow us to tell a broader story about the effectiveness of the different health education programs, as they relate to the success of students on the MEDscience Test for Content.

Another significant limitation to this study was inherited through the method of data collection and the software chosen to do such data collection. Many students took the liberty of being anonymous in their MEDscience Test for Content submission. It was not discovered until after data collection for Trial 1 was underway that the software used did not track Pre-MEDscience and Post-MEDscience scores for each individual student, instead, it treated them as two independent entries. While that was ok for the Non-MEDscience cohort, because this population was independent of the MEDscience students, this created a break in assumptions for our Pre-MEDscience to Post-MEDscience analysis, as we could not treat all of them as a paired group. This required us to treat the overall Pre-MEDscience and Post-MEDscience cohorts as independent in our full study analysis, even though they were mostly the same students. Therefore, the assumption that the two groups are in fact independent for the test statistic was broken. Ultimately 9 out of 22 students from Trail 2 who took the Pre-MEDscience Test for Content allowed us to track their progress over the course of the program and we could treat them as a paired group for analysis and use this smaller cohort in AIM III to measure growth as it compared to participation. In addition, there was little incentive for students to perform well and provide thorough responses on the MEDscience Test for Content. Because of this, student's may have omitted known details in a response, or some wrote "etc." instead of elaboration simply to finish the assessment faster. Had there been a stronger incentive for students to perform well, the level of effort and detail in the written responses may have been greater. In AIM II, a small cohort of 12 teachers from both public and private schools were surveyed about the current health program, as well as additional implicit health-related content covered in other courses at their school. Both small sample sizes proved to be a significant limitation and something to consider when looking into future studies.

Another factor that could have influenced this data was the age and timing of the sample pool. Being a group of seniors, many of whom have already been admitted to college, perhaps the level of dedication to their academic studies decreased as the semester transpired, as many of them were learning of college admittances.

Future Studies

To move forward with this research, we suggest first an increase in both student and teacher sample size. An increase in student sample size, along with collecting additional information about the student (school, age, demographics) would allow us to make conclusions about the growth of students in the program and how it relates to other aspects of their lives and their learning. By increasing teacher sample size, we could get a better understanding of current of health education programs and how they vary by state. Therefore, a future study could look at a comparison analysis of all mandatory health science courses and how they relate to student success nationwide on a standardized test like the MEDscience Test for Content, that is aimed to address aspects of health literacy.

Allocating funds into improving health education is not an easy task, but to encourage a future study that investigates this program and health literacy levels as they compare to healthcare expenditures could be done. This would help justify policy changes and distribution of government financial education resources. This study has provided us with many clues about what graduating high school students know, how their knowledge relates to their health literacy, as well as successful modes for teaching this knowledge. To have policy change, at a nationwide level, to improve health literacy and lower health care expenditures, we first must be aware of the current state of our young adult population. This cannot be done solely by researching curriculum frameworks and assuming that what is published is taught, and then what is taught is learned by the student. We must survey the students, the schools, and the teachers, to get an honest pulse of where health literacy education stands in our society so that we may make informed choices as to how to improve it.

Appendices

Appendix A: MEDscience Test for Content

The MEDscience Test for Content was given in electronic form, as a google survey. Below is a list of the questions and NHS Standards they met.

MEDscience Content Test Directions: This test consists of seven open-response item assignments. As a whole, your response to each assignment must demonstrate an understanding of the knowledge of the subject. In your response to each assignment, you are expected to demonstrate the depth of your understanding of the subject area by applying your knowledge rather than by merely reciting factual information.	
1. Jane Miller, a 48-year-old woman, came to the emergency room complaining of a severe headache. As a medical professional, think about what you would ask Jane to help you figure out what is wrong with her. (2.1, 2.13, 2.22, 4.11, 10.11)	
Sub-question	NHS Standard
Question 1a: What type of information might help you figure out what is wrong with her?	1.21c, 8.12, 8.23
Question 1b: What information would you need about the patient's physiology and history? (INTERVIEW)	1.21c, 4.11
Question 1c: Describe the situation that caused these symptoms? (CONTEXT)	1.21c 2.22a
Question 1d: What, besides questions, might you analyze to help obtain some objective (factual) data about the patient? (VITALS)	1.21c, 1.31, 1.32, 10.11, 2.22a
2. Nurse presents to you the vital signs from three of your patients found in Figure 1. (1.13d, 1.13f, 1.21, 1.32, 2.21, 2.22)	
Question 2a: Describe the normal ranges for each of the vital signs below.	1.32, 2.22a, 9.1, 10.11
Question 2b: Describe each patient's condition based on their vitals. Would you characterize it as stable, serious or critical?	1.32, 4.21c
Question 2c: Determine which of one these patients you would be most worried about? Explain why.	2.22a, 4.21c, 4.21k
3. Where in the lungs, specifically, is the site of oxygen/gas exchange? Describe how diffusion is the reasoning behind proper gas exchange. (1.11)	
Question 3a: What about the area of gas exchange is so important?	1.11b, 1.11c, 1.12c, 1.13f
Question 3b: Describe how smoking could alter this gas exchange	1.11c, 1.13f, 1.21

Question 3c: Describe the role hemoglobin play in gas exchange.	1.11a, 1.13f
Question 3d: What are the gases being exchanged in the lungs?	1.11a, 1.13f
4. If a patient with a breathing issue receives medication through an inhaler (orally), how will the medication enter the patient's bloodstream? (1.11, 1.13f, 1.13d, 1.21d, 10.1)	
Question 4a: Think of the anatomy of the respiratory system, what structures would the air pass through?	1.13f
Question 4b: What is the final structure that will aid in the medicine reaching the bloodstream?	1.11, 1.13f,1.21d
Question 4c: What is the process that describes how the medication enters the bloodstream?	
Question 4d: What are some additional effects an inhaler can have on a patient?	1.21d, 1.13d, 9.12f
Question 4e: Considering these consequences, why is it still important to administer the inhaler (in most scenarios)?	1.13f, 1.13d, 8.12e, 1.21d, 4.11
5. The circulatory system is a complex network of blood vessels responsible for delivering necessary gases and nutrients to the entire body. (1.11d, 1.13d, 1.21)	
Question 5a: List the three types of blood vessels.	1.13d
Question 5b: In which blood vessel is blood pressure highest? Lowest?	1.13d, 1.32
Question 5c: Which blood vessel allows for gas exchange?	1.11c, 1.13d
Question 5d: What are the consequences of a blood vessel blockage? What happens to these cells?	1.13d, 1.21b
Question 5e: Describe the type of circulation that would be disrupted due to a blockage in the: a) Aorta: b) Pulmonary Artery: c) Coronary Artery.	1.11b, 1.13d, 1.21b
Question 5f: Which blockage would be most concerning for the patient? Explain why.	1.21b
6. What symptoms and disease could result from a blockage in one coronary artery? Explain. (1.21b)	
Question 6a: Which organ is most affected in the coronary system?	1.11d, 1.13d
Question 6b: What are some treatment options for this medical issue?	1.21d
7. The endocrine system is a network of glands and chemical hormones that work together with the circulatory system to react to stimuli and maintain homeostasis in the body. (1.11d, 1.13i)	
Question 7a: What are the 8 glands of the endocrine system?	1.11d, 1.13i
Question 7b: Give an example of two glands that work together to maintain the homeostasis of a certain molecule or process.	1.11d, 1.13i
Question 7c: Describe a negative feedback loop and give an example	1.11a, 1.13i

8. There are two types of hormones: steroid and peptide hormones. (1.11a, 1.13i)	
Question 8a: Describe how hormones work.	1.11a, 1.13i
Question 8b: Explain why there are two types of hormones and give examples of both	1.11a, 1.13i
Question 8c: Choose a specific hormone and explain its role in the body	
9. You are being chased by a bear. This is very scary. This is about how your body would react. (1.13, 9.12)	
Question 9a: List your various body responses to this fear.	1.13g, 1.13h, 9.12f
Question 9b: Indicate which branch of the nervous system is activated. Is this branch autonomic or somatic? What does that mean?	1.13g
Question 9c: Describe a situation where another branch of this system would be activated. What is this branch called?	1.13g
Question 9d: What is the process of your body returning to normal. What is this normal state called? How does your body return to normal once you are no longer afraid?	1.13i, 1.13g
10. Imagine you are exposed to a pathogen (something bad). How do you think your body works to protect you? (1.11, 1.13, 9.12)	
Question 10a: Name all of the lines of defense from the immune system the pathogen may encounter.	1.11b, 1.11a, 1.13e
Question 10b: Which of these defense mechanisms are you born with (innate), and which mechanisms require your body to learn (adaptive)	1.13e, 9.12d
Question 10c: Do all defense mechanisms consist of cells? (1.11b, 1.11a, 1.13c)	
Question 10d: Are all lines of defense inside the body? If not, explain why or which one.	1.11f, 1.11c, 1.13e
11. It is important for your body to maintain homeostasis because many of the processes that happen in your body require a specific range to work optimally. 1.11e, 1.13, 9.11	
Question 11a: Describe a process your body uses to maintain homeostasis? Use at least 2 body systems in your example.	1.11e, 1.13, 9.11
Question 11b: What is the difference between negative and positive feedback?	1.13i
Question 11c: Why must your body maintain homeostasis?	

Appendix B: School Leader Survey

The School Leader Survey was given to high school science and health teachers across the United States. It was administered electronically, as a google survey.

Health Literacy Teacher Survey
Is your school public or private? • Public • Private
1A. What does health education look like at your school? Check all that apply: • Health class that stands alone from other classes • Required for graduation • Health class combined with physical education • Meets weekly • One semester long • One year long • Multiple semesters over multiple years • No specific course, material covered in variety of other courses • Other
1B. At what age does your current health curriculum end? • Middle School • 9th Grade • 10th Grade • 11th Grade • 12th Grade • Other
1C. Do you have a specific health education course at your school? • Yes • No
1D. If so, how often does this health course meet? (short answer)
1E. If so, which human systems are covered in this health course? • Skeletal • Muscular • Nervous • Endocrine • Respiratory • Cardiovascular • Immune • Excretory • Integumentary • Reproductive • Digestive • Urinary
1E2. If so, does this course cover the human systems in a diseased state? (ex. cardiovascular system and heart disease) • Yes • No • A little bit

1F. Are there assessment requirements for this health course? • Yes • No • Maybe
1G. Are health topics covered in other courses offered at your school? • General Science • Biology • AP Biology • Anatomy and Physiology • Physical Education • I don't know • Other
1G2. Are disease topics covered in the additional course offered at your school (from questions 1G)? • Yes • No • A little bit • I don't know
1H. To your knowledge, which systems are covered in other REQUIRED courses offered at your school? • Skeletal • Muscular • Nervous • Endocrine • Respiratory • Cardiovascular • Immune • Excretory • Integumentary • Reproductive • Digestive • Urinary
Curriculum Implementation: Schools implement the MEDscience sessions at Harvard Medical School into their curriculum in different ways. The next set of questions is designed to target how your school implements the program. If you do not have a MEDscience program, please answer the questions based on the course YOU teach.
1. Do you have a dedicated MEDscience class at your school? • Yes • No
2. If no, please select the course that you teach below, and answer the following questions as they pertain to the course you teach. • Biology • AP Biology • Anatomy and Physiology • Earth Science • Introductory Science • MEDscience • Other
3. Do you cover all seven units in the MEDscience curriculum? Check all that you cover: • Vitals • Respiratory • Cardiovascular • Endocrine • Digestive

• Nervous • Immune
4. How are your students assessed on their knowledge? Check all that apply: • Participation • Test/Quizzes • Reflections • Homework/Classwork • Other
5. Are students given additional case studies in class to practice applying their knowledge of the human body? • Yes • No • Maybe
6. In the respiratory system, check all that you cover: • Anatomy • Transport of gases • Inter and intrapulmonary pressure • The process of breathing • Surface area to volume ratio • Respiratory diseases • Other
7. In the cardiovascular system, check all that you cover: • Anatomy of the heart • Anatomy of the blood vessels • Pulmonary, systemic, and coronary systems • Cardiovascular diseases
8. In the endocrine system, check all that you cover: • All glands • All hormones • Some glands and hormones • Tropic vs. nontropic hormones • Negative feedback loop • Relationship between insulin and glucagon with glucose regulation • Relationship between parathyroid and thyroid with Ca+ regulation • Relationship between anterior pituitary and thyroid with T3 T4 regulation • Hyper vs. hypo secretion • Endocrine diseases
9. In the digestive system, check all that you cover: • Anatomy • Mechanical vs. chemical digestion • All proteins that break down food, where they are secreted from and where they do their job • Difference between nutrients, vitamins, and minerals 1. Carbohydrates, lipids, and proteins 2. Fat soluble and water-soluble vitamins, where they come from and how they help the body 3. Different minerals, their sources and their uses 4. Digestive issues (ex. Appendicitis, gallstones, obesity)
10. In the nervous system, check all that apply • Anatomy of a neuron • Classification of neurons • Supporting cells within the nervous system • Organization of both PNS and CNS • Reflex Arc • Action potential, or conduction down an single neuron

• Neural Synapse, conduction between neurons • Organization of the brain • Lobes, functional cortex regions • Anatomical directions • Issues of addiction and how that can change the neurochemistry of the brain
11. In the immune system, check all that apply • 3 lines of defense • Barrier defenses • Innate cellular defenses • Inflammatory response • Adaptive immunity • Passive and Active Immunity • Role of the lymphatic system • Allergies

Appendix C: Participation Rubric

The Student Participation Rubric was used by the teacher during each experiential session at Harvard Medical School (HMS) to score the student's level of participation in multiple categories. As mentioned in chapter II, students were scored between 0-3 for each category.

Student Participation During the Session	NHS Standards	NGSS Practices	Student 1	Student 2
Student modeled verbal communication with peers and adults (problem solving, discussing diagnosis, etc.)	2.11, 2.15, 2.2	Asking questions and defining problems		
Student modeled nonverbal communication (writing on the board, analyzing patient responses)	2.11	Analyzing and interpreting data. Using mathematics and computational thinking		
Student asked questions and analyzed vitals to help add information to "the board"	2.13, 2.3	Analyzing and interpreting data. Using mathematics and computational thinking. Obtaining, evaluating, and communicating information.		
Student modeled teamwork by communicating ideas off of each other to reach potential diagnoses.	2.15, 2.2	Asking questions and defining problems. Analyzing and interpreting data. Using mathematics and computational thinking. Engaging in arguments for evidence.		
Student effectively communicated with the patient	2.16, 2.2	Constructing explanations and designing solutions		
Student demonstrated safe/proper technique towards treating the patient (7.1, 7.2)	7.1, 7.2			

Terminology, use of	2.2	Engaging in arguments for evidence. Analyzing and interpreting data. Asking questions and defining problems		

Appendix D: Formative Assessment: MEDscience, *The Experience*

MEDscience, *The Experience* was a formative assessment given to each student electronically as a google survey after their completion of an HMS experiential session.

MEDscience, *The Experience*	NHS Standard
Name:	
Date:	
MEDscience Lesson: (drop down menu where students selected the session) • Lesson 1: Vitals • Lesson 2: Respiratory Case • Lesson 3: Intubations • Lesson 4: Cardiovascular Case • Lesson 5: IV's • Lesson 6: Endocrine Case • Lesson 7: Suturing • Lesson 8: Career Day • Lesson 9: Gastrointestinal Case • Lesson 10: Trauma Case • Lesson 11: Nervous Case	
1. How familiar were you with today's topic prior to the session? 1(completely unfamiliar) – 5(very familiar)	2.13, 4.11
2. How confident do you feel about the concepts you learned today? 1 (not confident)-5 (very confident)	2.13, 4.11
3. What was the objective of the session today? What is the main skill and/or concept you learned today? Summarize what you learned today. (student open response)	1.21
4. How would you rate your level of participation in the session? • I did not participate at all • I participated by listening, but did not actively engage with my team • I was and engaged participant that listened to team members and offered suggestions • was an engaged participant that talked more than I listened	2.11, 2.15, 4.11, 4.41, 8.1, 8.21

• I was an engaged participant that did not listen to other perspectives	
5. In what ways did you participate? Check all that apply: • Talk to the patient (ask questions) • Analyze test results • Write objective and subjective data on the board • Discuss possible diagnosis • Participate in the pre-lecture • Participate in the debrief	1.21, 1.32, 2.2, 4.11 4.2, 8.12
6. How comfortable did you feel around the patient, helping the patient? 1 (very uncomfortable) -5 (totally comfortable)	2.11, 2.16, 2.2, 3.12, 4.11, 4.21, 6.1, 8.12
7. How comfortable did you feel in analyzing the medical tests you ordered during this session? 1 (no idea what the tests were and say) -5 (very comfortable understanding medical tests)	1.32, 4.21
8. Compared to learning that happens in the classroom, how does learning in this way/environment compare? (student open response)	2.22, 4.11, 4.21, 8.1, 8.2
9. What safety procedures did you learn (or must use) to ensure the safety of you, your team, and your patient? (student open response)	7.22, 7.31, 9.1
10. What was most challenging for you during this session? (student open response)	
11. What could have helped you understand the concepts more thoroughly? (student open response)	4.11

Appendix E: Health Literacy Content Knowledge Rubric

The Health Literacy Content Knowledge Rubric (HLKNR) was built to quantitatively assess student responses to the MEDscience Test for Content assessment. Students were scored from 0-5 according to their answers and how they aligned with the rubric. Notice, some areas are shaded in, indicating that numerical value did not apply to a response.

Grading Scale 0-5 Descriptions

Score	Category	Descriptor

0		Question left blank, contained "I don't know," or response was incorrect.
1	Incomplete	Response demonstrated little understanding of concept relative to question asked.
2	Below Average	Response demonstrated very brief understanding through the inclusion of one key point or detail stated.
3	Average	Response demonstrated general understanding of the content, with no indication of detail or application of the concepts.
4	Above Average	Response demonstrated higher understanding through the inclusion of specific detail or application of the concept.
5	Mastery	Response demonstrated highly proficient understanding of the concept through the inclusion of all required components as well as application of the concepts when applicable.

	National Health Science Standard	0	1 Incomplete	2 Below Average	3 Average	4 Above average	5 Mastery
1. Jane Miller, a 48-year-old woman, came to the emergency room complaining of a severe headache. As a medical professional, think about what you would ask Jane to help you figure out what is wrong with her. (2.1, 2.13, 2.22, 4.11, 10.11)							
Question 1a: What type of information might help you figure out what is wrong with her?	1.21c, 8.12, 8.23		Response includes "what happened."	Brief, basic, general information. Ex. vitals, what happened	Criteria outlined in 2 in addition to history of present illness (what hurts).	Criteria outlined in 3 in addition to minimal background information on patient.	Criteria outlined in 4 as well as all background information (subjective data) on patient.
Question 1b: What information would you need about the patient's physiology and history? (INTERVIEW)	1.21c, 4.11		One test or topic. Ex. History of present illness (HPI)	Basic tests or questions. Ex. Age, weight, gender	Few tests or questions listed with no elaboration. Ex. Allergies, medication	Numerous tests, some elaboration. Ex.: Surgeries, family medical history	Multiple types of questions with elaboration covering all aspects of the patient. Ex. Vitals, patient history (allergies, social, surgical, familial, medical)

Question 1c: Describe the situation that caused these symptoms? (CONTEXT)	1.21c 2.22a		Identification of diagnosis without description. Ex. concussion	Context of situation with no description tying context to symptoms.	History of present illness described with one reason for symptoms mentioned.	Criteria outlined in 3 with two reasons for symptoms.	Full history of present illness with multiple (3+) reasons for current symptoms explained.
Question 1d: What, besides questions, might you analyze to help obtain some objective (factual) data about the patient? (VITALS)	1.21c, 1.31, 1.32, 10.11, 2.22a		1 vital mentioned	2 vitals mentioned	3 vitals mentioned	4 vitals mentioned	All 5 vitals mentioned: -blood Pressure -temperature -heart rate/pulse -respiratory rate -O2 saturation
2. Nurse presents to you the vital signs from three of your patients found in Figure 1. (1.13d, 1.13f, 1.21, 1.32, 2.21, 2.22)							
Question 2a: Describe the normal ranges for each of the vital signs below.	1.32, 2.22a, 9.1, 10.11		Accurate description of temperature only.	Criteria outlined in 1 in addition to heart rate and pulse.	Criteria outlined in 2 in addition to blood pressure.	Criteria outlined in 3 in addition to respiratory rate or oxygen saturation.	Student accurately describes all five vitals: temperature, heart rate, blood pressure, respiratory rate and oxygen saturation.
Question 2b: Describe each patient's condition based on their vitals. Would you characteri	1.32, 4.21c		One patient's description, no characterization.	Patient descriptions but no characterization (stable, serious, critical).	Stable, serious, critical characterization but no description. Response includes a general statement about what is "high."	Patient characterization with some concerning aspects about vitals discussed with terms but not all for all	Correct condition with detailed descriptions for all patients.

ze it as stable, serious or critical?						three patients.	
Question 2c: Determine which of one these patients you would be most worried about? Explain why.	2.22a, 4.21c, 4.21k		Incorrect patient identified, however reasoning behind identificati on indicates some learning.	Patient C stated, without description .	Patient C stated, brief additional description.	Patient C stated with description including evidence. Ex. due to low RR and age	Patient C stated, response includes low RR, age, and other factors. Additi onal recommendatio n that Patient B seek help.
3. Where in the lungs, specifically, is the site of oxygen/gas exchange? Describe how diffusion is the reasoning behind proper gas exchange. (1.11)							
Question 3a: What about the area of gas exchange is so important?	1.11b, 1.11c, 1.12c, 1.13f		It occurs in the lungs.	Criteria outlined in 1 in addition to "the lungs must be efficient."	Location of gas exchange (alveoli), and the movement of CO_2 and O_2.	Criteria outlined in 3 as well as the lungs must be thin for efficient gas exchange.	Criteria outlined in 4 as well as high surface area to volume ratio. Student could have discussed the concentration gradient of CO_2 and O_2.
Question 3b: Describe how smoking could alter this gas exchange	1.11c, 1.13f, 1.21		Statement that smoking is not good and/or could kill you.	Statement that the lungs becoming "clogged" and/or breathing is more difficult.	Statement that smoking is bad for cells, or that it decline/worsens/s uppress gas exchange.	Statement includes the decrease in surface area to volume ratio and/or that smoking leads to lung disease.	Statement includes any of the following: alveoli breaking, decrease of surface area to volume ratio, hardening of alveoli, cilia inhibition, or emphysema.
Question 3c: Describe the role hemoglobi n play in gas exchange.	1.11a, 1.13f		Good for gas exchange	Hemoglob in helps O_2	Hemoglobin binds to O_2	Hemoglobi n is a protein and carries O_2 through the body.	Criteria in 4. The more hemoglobin, the more gas exchange.

Question 3d: What are the gases being exchanged in the lungs?	1.11a, 1.13f		Only mention one, CO_2 or O_2.		CO_2 and O_2		
4. If a patient with a breathing issue receives medication through an inhaler (orally), how will the medication enter the patient's bloodstream? (1.11, 1.13f, 1.13d, 1.21d, 10.1)							
Question 4a: Think of the anatomy of the respiratory system, what structures would the air pass through?	1.13f		Lungs.	General structures or only two included.	Three or four of the seven structures included.	Five or six of the seven structures included.	All seven structures: Mouth, pharynx, larynx, trachea, bronchi, bronchioles, and alveoli included.
Question 4b: What is the final structure that will aid in the medicine reaching the bloodstream?	1.11, 1.13f,1.21d			Lungs or blood vessels			Alveoli
Question 4c: What is the process that describes how the medication enters the bloodstream?				Absorption	Diffusion		
Question 4d: What are some additional effects an	1.21d, 1.13d, 9.12f			No effects listed, but additional information about an	Other physiological symptoms not as crucial described.	Death with description.	Elevated heart rate, blood pressure.

inhaler can have on a patient?				inhaler are given.			
Question 4e: Considering these consequences, why is it still important to administer the inhaler (in most scenarios)?	1.13f, 1.13d, 8.12e, 1.21d, 4.11			To allow the patient to breathe.	Need O2 first. No additional information explaining this concept given.	Need O2 because it is essential for life.	The need for O2 is most important, the heart attack can be managed.
5. The circulatory system is a complex network of blood vessels responsible for delivering necessary gases and nutrients to the entire body. (1.11d, 1.13d, 1.21)							
Question 5a: List the three types of blood vessels.	1.13d		One vessel stated.	Two of three vessels stated.	Veins, arteries, and capillaries.		
Question 5b: In which blood vessel is blood pressure highest? Lowest?	1.13d, 1.32			One of two blood vessels mentioned. Correctly identified.	Highest: arteries Lowest: veins	Highest: arteries Lowest: veins Additional information included. Ex. Thickness of walls, direction of blood flow, etc.	
Question 5c: Which blood vessel allows for gas exchange?	1.11c, 1.13d		Lungs		Capillaries		
Question 5d: What are the	1.13d, 1.21b		Bad for cells.	Death or blood clots.	Heart attack, no explanation.	Heart attack, short	Detailed response, including the

consequences of a blood vessel blockage? What happens to these cells?						explanation.	concept that cells beyond the blockage cannot receive O2.
Question 5e: Describe the type of circulation that would be disrupted due to a blockage in the: a) Aorta: b) Pulmonary Artery: c) Coronary Artery.	1.11b, 1.13d, 1.21b		One correct.	Two correct or one correct with detailed explanation.	All three correct with no explanation.	All three correct and brief explanation.	All three correct and explained in detail.
Question 5f: Which blockage would be most concerning for the patient? Explain why.	1.21b			Pulmonary or systemic but without sufficient reasoning.	Coronary blockage, no description.	Coronary blockage or heart with brief explanation.	Coronary blockage or heart. Explanation includes the role of the system to pump blood and deliver O2 to heart.
6. What symptoms and disease could result from a blockage in one coronary artery? Explain. (1.21b)							
Question 6a: Which organ is most affected in the coronary system?	1.11d, 1.13d				Heart		
Question 6b: What are some treatment	1.21d		One mentioned with no detail.	Two options mentioned	Two options mentioned, one being surgery.	General overview of diet and surgery.	Diet, blood thinners, medications,

options for this medical issue?				and no surgery.			and surgery (both types)
7. The endocrine system is a network of glands and chemical hormones that work together with the circulatory system to react to stimuli and maintain homeostasis in the body. (1.11d, 1.13i)							
Question 7a: What are the 8 glands of the endocrine system?	1.11d, 1.13i		One gland included.	Two glands included.	Three or four of eight glands included.	Five or six of eight glands included.	Seven or Eight of the following glands mentioned: Pineal, anterior pituitary, posterior pituitary, thymus, thyroid, parathyroid, pancreas, adrenals, gonads.
Question 7b: Give an example of two glands that work together to maintain the homeostas is of a certain molecule or process.	1.11d, 1.13i			Discussion of one gland involved but not the second.	Correct identification of glands but no explanation.	Correct identificati on with brief explanatio n.	Correct identification and detailed explanation.
Question 7c: Describe a negative feedback loop and give an example	1.11a, 1.13i		Identified example only. No explanation of concept.	Example identified and briefly explained. No explanatio n of concept.	Detailed example or detailed description.	Descriptio n of negative feedback with brief example.	Description of negative feedback and thorough example.
8. There are two types of hormones: steroid and peptide hormones. (1.11a, 1.13i)							
Question 8a: Describe	1.11a, 1.13i		Discussion of one way	Incomplet e statement	General statement about hormones being	Detailed description of	Criteria from 4 in addition to details around

how hormones work.			hormones work Ex. Hormones makes things happen.	about hormones. Ex. Hormones are chemical signals.	chemicals in the body that cause the body to respond.	chemical messengers that initiate response in the body in specific ways.	the two types and the communication with target cells.
Question 8b: Explain why there are two types of hormones and give examples of both			Target different cells.	Correct types but vague or partially correct with the details.	Steroid and nonsteroid, has to do with the communication with cells.	Criteria outlined in 3 in addition to detail in how they work in different ways.	Two types have different release speeds, target the cell different ways and/or are steroid and protein based. Steroid are direct activation.
Question 8c: Choose a specific hormone and explain its role in the body			Identification of hormone only.	Identification without explanation.	General statement about the target of the hormone.	Significant detail about the hormone, how it works, the cells it affects.	Criteria outlined in 4 in addition to the gland it is secreted from and other effects the hormone may have.
9. You are being chased by a bear. This is very scary. This is about how your body would react. (1.13, 9.12)							
Question 9a: List your various body responses to this fear.	1.13g, 1.13h, 9.12f		One response	Few responses or simply, “adrenaline or fight or flight.”	General statement including more than two responses.	Detailed response with terms used for the responses.	Response identifies division: autonomic or sympathetic division as well as the following body responses: Increased heart rate and blood pressure, dilation of the eyes, relaxation of the bladder, dilation of the lungs and lung capillary beds, vasoconstriction of some

							blood vessels. Digestion ceases. Adrena line is suppressed from the adrenal glands.
Question 9b: Indicate which branch of the nervous system is activated. Is this branch autonomic or somatic? What does that mean?	1.13g		Identificati on of either branch or autonomic or somatic only.	Identificati on of both branches, or incorrectio n identificati on but correct explanatio n	Autonomic, general explanation.	Sympathet ic, Autonomic , general explanatio n (fight or flight accepted here).	Sympathetic, Autonomic, correct explanation of the division and application to the question.
Question 9c: Describe a situation where another branch of this system would be activated. What is this branch called?	1.13g		Explanatio n and no identificati on.	Identificati on and no explanatio n.	Somatic or parasympathetic with general explanation.		Somatic or parasympatheti c with detailed description
Question 9d: What is the process of your body returning to normal. What is this normal state called? How does your body	1.13i, 1.13g		General description.	Homeostas is identificati on only, or detailed description .	Homeostasis identification with brief explanation.		Homeostasis, negative feedback, with detailed explanation

return to normal once you are no longer afraid?							
10. Imagine you are exposed to a pathogen (something bad). How do you think your body works to protect you? (1.11, 1.13, 9.12)							
Question 10a: Name all of the lines of defense from the immune system the pathogen may encounter.	1.11b, 1.11a, 1.13e		Random immune terms. Ex. "white blood cells"	Some understanding of one line of defense.	General statement demonstrating some understanding of all three line of defense. No specific detail about what is included in each line of defense given.	Name two of three lines of defense with accurate description of both with detail.	All three lines of defense described with detail. Details may include information listed below: 1st: Barrier Defenses (innate): Skin, mucus membranes, secretions. Broad ranges of pathogens, rapid response 2nd: Internal Innate: Phagocytic cells, natural killer cells, antimicrobial Proteins (Broad recognition range), inflammatory response (rapid response) 3rd: Adaptive Humoral: Antibodies in cellular fluid Cell Mediated: T Cell and B Cell recognition and response (Recognition of traits to specific pathogen once antigen presented on

							dendritic cell, slower response)
Question 10b: Which of these defense mechanisms are you born with (innate), and which mechanisms require your body to learn (adaptive)	1.13e, 9.12d		One example of either innate or adaptive.	Basic description of either innate or adaptive.	Basic description of innate and adaptive with identification example of each.		Detailed description of both innate and adaptive as well as examples of each that are explained.
Question 10c: Do all defense mechanisms consist of cells?	1.11b, 1.11a, 1.13c				No		
Question 10d: Are all lines of defense inside the body? If not, explain why or which one.	1.11f, 1.11c, 1.13e			No	No, then mention of skin.	No, then mention of two ways the body fights the exterior. Brief explanation.	No, the first line of defense is fighting the exterior, either on your skin, in your mucus, saliva, or stomach. Explanation included.
11. It is important for your body to maintain homeostasis because many of the processes that happen in your body require a specific range to work optimally. (1.11e, 1.13, 9.11)							
Question 11a: Describe a process your body uses to maintain homeostasis? Use at least 2 body systems in	1.11e, 1.13, 9.11		Identification of how one body system maintains homeostasis. Or identification of two systems with no additional	Identification of two body systems but explanation of one.	Example includes two body systems working together with brief explanation.	Identification of feedback loops. Example includes two body systems and how they work together.	Identification and explanation of feedback loops. Detailed explanation of how two body systems work together.

your example.			information.				
Question 11b: What is the difference between negative and positive feedback?	1.13i			Description of one type of feedback.	Accurate description of one feedback system, attempt to compare it to the other but falls short.	Brief statement that identifies positive feedback as enhancing stimulus and negative feedback suppressing the stimulus.	Detailed explanation of both positive and negative feedback using an example.
Question 11c: Why must your body maintain homeostasis?				A specific example of the body being out of homeostasis.	Brief, simple, statement. Ex. "To stay alive"	General statement with little elaboration. Ex. "To ensure all body systems are working, to stay alive"	Detailed answer about efficiency of the body with an example.

Appendix F: MEDscience, *The Experience* Rubric

This rubric was designed to classify student open responses to questions from MEDscience, *The Experience* into bins, or categories, for quantitative analysis. It was developed by first reading all open responses and generating a list of categories where all responses would comfortably fit. Once categories were created, responses were tallied, and frequency of responses were determined.

What was the objective of the session today? What is the main skill and/or concept you learned today? Summarize what you learned today.		
Qualitative Categories	Quantitative Results (Tally, n)	Quantitative Results (%, n/total)
Skill/Concept simply stated		

Brief summary		
General summary with a few details about the experience		
Detailed summary with details showcasing student's ability to apply the concept/skill they learned to the system as a whole		

Compared to learning that happens in the classroom, how does learning in this way/environment compare?		
Qualitative Categories	Quantitative Results (Tally, n)	Quantitative Results (%, n/total)
Prefer		
Do not prefer		
Reasoning behind why student preferred the learning environment		
More realistic		
More hands-on		
More interesting, more engaging, more effective		
Other		

What safety procedures did you learn (or have to use) to ensure the safety of you, your team, and your patient?		
Qualitative Categories	Quantitative Results (Tally, n)	Quantitative Results (%, n/total)
None		
Respect		
Ask questions, speak up		
Sanitizer, gloves		
Technique based procedures		

What was most challenging for you during this session?		
Qualitative Categories	Quantitative Results (Tally, n)	Quantitative Results (%, n/total)
Skill		
Communication with patient		
Communication with team		
Problem solving, determining a diagnosis		
Environment		
Other		

What could have helped you understand the concepts more thoroughly?		
Qualitative Categories	Quantitative Results (Tally, n)	Quantitative Results (%, n/total)
Nothing		
More instruction/ preparation		
More practice		
More time		
More hands-on work		
Less people		
Other		

Appendix G: IRB Consent and Assent Forms

The following consent and assent forms were generated to ensure ethical standards for this study.

Child Assent Form for the Non-MEDscience student

ASSENT TO PARTICIPATE IN RESEARCH

The Importance of Health Literacy Programs at the High School Level

1. My name is Emilia Guy. I am a researcher at the Harvard Extension School.
2. We are asking you to take part in a research study because we are trying to learn more about student's knowledge on health literacy topics because I believe it is important for all young men and women to have a general understanding of common health issues that they may encounter, so they may better help themselves or a loved one. There are many programs available that schools have adopted. I am looking to compare the effectiveness of different programs in teaching health literacy. To do this, I am asking you and other graduating students to take part in my research study.
3. If you agree to be in this study I will ask you to take one one-hour content test that covers questions pertaining to health literacy, disease, and the human body.
4. The test might be a little frustrating for you if you do not know the answers, but there is no harm in participating in this study.
5. There will be no compensation for your participation.
6. Please talk this over with your parents before you decide whether or not to participate. We will also ask your parents to give their permission for you to take part in this study. But even if your parents say "yes" you can still decide not to do this.
7. If you don't want to be in this study, you don't have to participate. Remember, being in this study is up to you and no one will be upset if you don't want to participate or even if you change your mind later and want to stop.
8. You can ask any questions that you have about the study. If you have a question later that you didn't think of now, you can call me at 802-989-0069 or ask me next time.
9. Signing your name at the bottom means that you agree to be in this study. You and your parents will be given a copy of this form after you have signed it.

_______________________________________ _____________________

Name of Child Date

Child Assent Form for the MEDscience student

ASSENT TO PARTICIPATE IN RESEARCH

The Importance of Health Literacy Programs at the High School Level

1. My name is Emilia Guy. I am a researcher at the Harvard Extension School.

2. We are asking you to take part in a research study because we are trying to learn more about student's knowledge on health literacy topics because I believe it is important for all young men and women to have a general understanding of common health issues that they may encounter, so they may better help themselves or a loved one. There are a variety of health literacy programs that schools have adopted. One program I am investigating, is the effectiveness of the MedScience program on student's health literacy. To do this, I am asking you and other students taking MedScience at your school, to take part in my research study.

3. If you agree to be in this study I will ask you to take a few assessments throughout your MedScience course so that I can use these assessments as data in my study. These assessments are separate from your course and will not be graded or counted as a grade in your course. You will first take a pre-assessment content test, to try and find out how much you already know about the human body and common diseases prevelant in our society today. The test will include open-ended questions about the human body, as well as how you would help someone if they were acting a certain way or have particular symptoms. Then, after you have completed the MedScience course, you will take the same content test as a post-assessment. Finally, during the MedScience course, I will also ask you to take a short fifteen minute survey after each Harvard session to learn about your experience at the session.

4. The test might be a little frustrating for you if you do not know the answers, but there is no harm in participating in this study.

5. There will be no compensation for your participation.

6. Please talk this over with your parents before you decide whether or not to participate. We will also ask your parents to give their permission for you to take part in this study. But even if your parents say "yes" you can still decide not to do this.

7. If you don't want to be in this study, you don't have to participate. Remember, being in this study is up to you and no one will be upset if you don't want to participate or even if you change your mind later and want to stop.

8. You can ask any questions that you have about the study. If you have a question later that you didn't think of now, you can call me at 802-989-0069 or ask me next time.

9. Signing your name at the bottom means that you agree to be in this study. You and your parents will be given a copy of this form after you have signed it.

____________________________________ ____________________

Name of Child Date

Parent Guardian Consent Form

Study Title: The Importance of Health Literacy Programs at the High School Level.
Researcher: Emilia Guy
Faculty Advisor: Victor Pereira
Version Date: April 10, 2018

Key Information

The following is a short summary of this study to help you decide whether or not you want your child to be a part of this study. More detailed information is listed later on in this form.
If your child is in a MedScience program, participation for him/her will entail a pre- and post-assessment on content knowledge surrounding health literacy topics such as asthma, heart disease, diabetes, opioid addiction, and gallstones. In addition, your child will be formally assessed weekly after each MedScience session on their learning experience. If your child is not enrolled in MedScience program, participation will include (1) one-hour assessment on health literacy topics stated previously.

Why is my child being invited to take part in a research study?
We invite your child to take part in a research study because they are a graduating high school student.

What should I know about a research study?

- Someone will explain this research study to you and your child.
- Whether or not you take part is up to you and your child.
- Your child's participation is completely voluntary.
- You and your child can choose not to take part.
- You and your child can agree to take part and later change your mind.
- You and your child's decision will not be held against you.
- You and your child can ask all the questions you want before you decide.
-

Why is this research being done?

The purpose of this research is to evaluate the level of knowledge of health literacy topics such as diabetes, heart disease, and asthma in our graduating high school students across various, schools, curricula, and participation in "nontraditional" learning programs such as MedScience. The research will identify potential gaps in health education according to the National Health Science Standards and propose modifications to increase health literacy for students graduating high school.

How long will the research last and what will my child need to do?

If your child is a MedScience student:

We expect that your child will be in this research study for one semester (roughly four-month participation will take place during their MedScience course at school.

The MedScience course will run as it is designed, including class and weekly sessions at Harvard. If your child participates in this study it would be by asking them to complete pre- and post-content assessments before and after the program, and weekly formative assessments at the conclusions of each Harvard MedScience session. The pre- and post- content tests and the formative assessments are the methods of collecting data for this study.

If your child is not a MedScience student:

We expect that your child will be in this research study for one hour, during which time he/she will complete a content assessment made up of open-response style questions meant to evaluate their knowledge on specific health literacy topics. The student will not be in the MedScience course.

Is there any way being in this study could be bad for my child?
Your child may experience normal frustration associated with test taking when trying to complete the content test.

Will being in this study help my child in any way?
There are no benefits to your child from your taking part in this research. We cannot promise any benefits to others from your child taking part in this research. However, possible benefits may include light snacks or refreshments.

Detailed Information

The following is more detailed information about this study in addition to the information listed above.

What is the purpose of this research?

The purpose of this study is to gain an understanding of what types of health literacy programs are offered at the high school level, what the students are learning in these programs or in other high school courses pertaining to health literacy, and to prove health literacy programs such as MedScience adequately prepare high school students with essential knowledge and understanding of targeted health literacy topics. The questions that I hope to answer are:

1. What is the level of health literacy in graduating high school students across National Health Science Standards (NHSS)?
2. What is the effectiveness of different approaches to teaching health literacy?
3. How much have students improved in their health literacy across NHSS after taking MedScience?

With this information I plan to make recommendations to schools and their health curriculum strategy to ensure all students are leaving high school with an adequate level of health literacy.

How long will my child take part in this research?

If your child is a MedScience student:

We expect that your child will be in this research study for one semester (roughly four months), participation will take place during their MedScience course at school. This course will meet four days a week, one of which will be spent at Harvard Medical School participating in at simulation targeted at a specific health literacy topic.

Your child will be asked to attend class (50 minutes, three times a week) and sessions (75 minutes, once a week), complete pre- and post-content assessments (50 minutes), and weekly formative assessments (15 minutes) at the conclusion of each Harvard MedScience session.

If your child is not a MedScience student:

We expect that your child will be in this research study for one hour, during which time he/she will complete a content assessment made up of open-response style questions meant to evaluate their knowledge on specific health literacy topics.

What can I expect if my child takes part in this research?

If your child is a MedScience student:

Your child will learn about human anatomy systems in class through lecture, worksheets, and group activities. Once per week your child will travel to Harvard Medical School to participate in a MedScience session, where they will either learn a skill using manikins associated with medicine (intubations, how to give an IV, how to give someone stitches), or they will participate in a simulated medical case. The simulated medical case requires your child to work with their peers to diagnose a patient (the manikin). To diagnose this patient your student will have to ask the patient questions, run tests, measure vital signs, and collaborate with their peers. The classroom sessions will take place at your child's school, the MedScience sessions will take place at Harvard Medical School in Longwood Medical Center. At the beginning of the course your child will complete the pre-assessment content test, and at the end of the course your child with complete the post-assessment content test. In addition, after each Harvard session your child will complete a brief formative assessment that will allow your child to describe their experience. During the MedScience sessions your child's level of participation will be observed. Your child will interact with their teacher and the MedScience team of qualified professionals.

If your child is not a MedScience student:

Your child will participate in a one-time, hour-long, content test. The test will be administered at your child's school by a school faculty member.

What happens if I or my child say yes, but I or my child change our minds later?
Your child can leave the research at any time it will not be held against your child.

Is there any way being in this study could be bad for my child? (Detailed Risks)
There are some risks your child might experience from being in this study. Your child may experience normal frustration associated with test taking when trying to complete the content test.

If my child takes part in this research, how will their privacy be protected? What happens to the information you collect?

Efforts will be made to limit the use and disclosure of your child's personal information, including research study and medical records, to people who have a need to review this information. We cannot promise complete secrecy. Organizations that may inspect and copy your child's information include the IRB and other representatives of this organization. The MedScience program administrators may also view your child's name and date of birth only.

Your child's information or samples that are collected as part of this research will not be used or distributed for future research studies, even if all of your child's identifiers are removed.

Who can I talk to?
If you have questions, concerns, or complaints, or think the research has hurt your child, talk to the research team at:

Emilia Guy who can be reached at 802.989.0069, or emi17rose@gmail.com, or 541 Commercial St. Weymouth MA 02188.
The faculty sponsor is Victor Pereira who can be reached at 617.496.7233 or victor_pereira@gse.harvard.edu.

This research has been reviewed and approved by the Harvard University Area Institutional Review Board ("IRB"). You may talk to them at (617) 496-2847 or cuhs@harvard.edu if:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your child's rights as a research subject.
- You want to get information or provide input about this research.

Signature Block for Involvement of Children
Your signature documents your permission for the named child to take part in this research.

____
Printed Name of Child

____ ______________
Signature of Parent or Individual Legally Authorized to Consent to the Child's General Medical Care — Date

____
Printed Name of Parent or Individual Legally Authorized to Consent to the Child's General Medical Care

____ ______________
Signature of Person Obtaining Consent — Date

____
Printed Name of Person Obtaining Consent

Adult Faculty Consent Form

Study Title: The Importance of Health Literacy Programs at the High School Level.
Researcher: Emilia Guy
Faculty Advisor: Victor Pereira
Version Date: April 10, 2018

Key Information

The following is a short summary of this study to help you decide if to be a part of this study. More detailed information is listed later on in this form.

As a participant, you will be asked to answer questions about your experience in teaching health literacy programs, what state standards require you to teach, the depth in which you cover the topics, and what your level of interest in the topics are. Your students will complete a series of open-ended questions about medicine and treating those in need.

Why am I being invited to take part in a research study?

We invite you to take part in a research study because you teach health sciences, cover health science in one of your courses, or you are an administrator of the school.

What should I know about a research study?

- Someone will explain this research study to you.
- Whether or not you take part is up to you.
- Your participation is completely voluntary.
- You can choose not to take part.
- You can agree to take part and later change your mind.
- Your decision will not be held against you.
- You can ask all the questions you want before you decide.

Why is this research being done?

The purpose of this research is to evaluate the level of knowledge of health literacy topics such as diabetes, heart disease, and asthma in our graduating high school students across various demographics, schools, curricula, and participation in “nontraditional” learning programs. The research will identify potential gaps in health education according to the health education standards and propose modifications to increase health literacy for students graduating high school.

How long will the research last and what will I need to do?
We expect that you will be in this research study for twenty minutes.
You will be asked to complete a twenty-minute survey pertaining to the health literacy program(s) at your school.

Is there any way being in this study could be bad for me?
We don’t believe there are any risks from participating in this research. The survey is designed as an assessment on the depth and breadth of health literacy topics covered in your school’s curricula. Participation in survey may reveal areas of informed improvement to health literacy program.

Will being in this study help me in any way?
There are no benefits to you from your taking part in this research. We cannot promise any benefits to others from your taking part in this research.

Detailed Information

The following is more detailed information about this study in addition to the information listed above.

What is the purpose of this research?
The purpose of this study is to gain an understanding of what types of health literacy programs are offered at the high school level, what the students are learning in these programs or in other high school courses pertaining to health literacy, and to prove health literacy programs such as MedScience adequately prepare high school students with essential knowledge and understanding of targeted health literacy topics. The questions that I hope to answer are:

1. What is the level of health literacy in graduating high school students across National Health Science Standards (NHSS)?
2. What is the effectiveness of different approaches to teaching health literacy?
3. How much have students improved in their health literacy across NHSS after taking the program MedScience?

With this information I plan to make recommendations to schools and their health curriculum strategy to ensure all students are leaving high school with an adequate level of health literacy.

How long will I take part in this research?
Your participation will involve completing a twenty-minute survey pertaining to the health literacy program(s) and assisting in the distribution of content tests to your graduating students.

What can I expect if I take part in this research?
You can expect to answer questions pertaining to the way health literacy is taught at your school (explicit or implicit), the topics covered, and the level of understanding of the topics those who are teaching it have. You will interact with me, the primary investigator, the survey will be completed once, online, at your convenience.

What happens if I say yes, but I change my mind later?
You can leave the research at any time it will not be held against you.

If I take part in this research, how will my privacy be protected? What happens to the information you collect?
Efforts will be made to limit the use and disclosure of your personal information, including research study and medical records, to people who have a need to review this information. We cannot promise complete secrecy. Organizations that may inspect and copy your information include the IRB and other representatives of this organization.
Your information or samples that are collected as part of this research will not be used or distributed for future research studies, even if all of your identifiers are removed.

Who can I talk to?

If you have questions, concerns, or complaints, or think the research has hurt you, talk to the research team at:

Emilia Guy who can be reached at 802.989.0069, or emi17rose@gmail.com, or 541 Commercial St. Weymouth MA 02188.

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- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your rights as a research subject.
- You want to get information or provide input about this research.

Signature Block for Adult Subject

Your signature documents your permission to take part in this research.

______________________________ ______________

Signature of Subject Date

____

Printed Name of Subject

______________________________ ______________

Signature of Person Obtaining Consent Date

____

Printed Name of Person Obtaining Consent

Signature Block for Adult Subject Providing School Consent

By signing this consent form, you give permission for your school to be used in this study. Please remember all personal information concerning study subjects will be eliminated from this study, and it will remain completely anonymous.

Your signature documents your permission for the school to take part in this research.

______________________________ ______________

Signature of Subject (School Leader) Date

____

Printed Name of Subject (School Leader)

______________________________ ______________

Signature of Person Obtaining Consent Date

____

Printed Name of Person Obtaining Consent

Appendix H: National Health Science Standards

The National Health Science Standards were used to standardize many assessments and rubrics used in this study.

NATIONAL HEALTH SCIENCE STANDARDS

May 2015

The National Health Science Standards provide a clear and consistent understanding of industry and post-secondary expectations for health science teachers and students. These standards are designed to provide the essential knowledge common across health professions to prepare and increase the number of students that are college and career ready.

Foundation Standard 1: Academic Foundation

Understand human anatomy, physiology, common diseases and disorders, and medical math principles.

1.1 Human Anatomy and Physiology

1.11 Identify basic levels of organization of the human body.

a. Chemical
b. Cellular
c. Tissue
d. Organs
e. Systems
f. Organism

1.12 Identify body planes, directional terms, cavities, and quadrants.

a. Body planes (sagittal, mid-sagittal, coronal/frontal, transverse/horizontal)
b. Directional terms (superior, inferior, anterior/ventral, posterior/dorsal, medial, lateral, proximal, distal, superficial, and deep)
c. Cavities (dorsal, cranial, spinal, thoracic, abdominal, and pelvic)
d. Quadrants (upper right, lower right, upper left, and lower left)

1.13 Analyze basic structures and functions of human body systems (skeletal, muscular, integumentary, cardiovascular, lymphatic, respiratory, nervous, special senses, endocrine, digestive, urinary, and reproductive).

a. Skeletal (bone anatomy, axial and appendicular skeletal bones, functions of bones, ligaments, types of joints)
b. Muscular (microscopic anatomy of muscle tissue, types of muscle, locations of skeletal muscles, functions of muscles, tendons, directional movements)
c. Integumentary (layers, structures and functions of skin)
d. Cardiovascular (components of blood, structures and functions of blood components, structures and functions of the cardiovascular system, conduction system of the heart, cardiac cycle)
e. Lymphatic (structures and functions of lymphatic system, movement of lymph fluid)
f. Respiratory (structures and functions of respiratory system, physiology of respiration)
g. Nervous (structures and functions of nervous tissue and system, organization of nervous system)
h. Special senses (structures and functions of eye, ear, nose and tongue; identify senses for sight, hearing, smell, taste, touch)
i. Endocrine (endocrine versus exocrine, structures and functions of endocrine system, hormones, regulation of hormones)
j. Digestive (structures and functions of gastrointestinal tract, chemical and mechanical digestion, structures and functions of accessory organs)
k. Urinary (structures and functions of urinary system, gross and microscopic anatomy, process of urine formation, urine composition, homeostatic balance)

l. Reproductive (structures and functions of male and female reproductive systems, formation of gametes, hormone production and effects, menstrual cycle, and conception)

1.2 Diseases and Disorders

1.21 Describe common diseases and disorders of each body system (such as: cancer, diabetes, dementia, stroke, heart disease, tuberculosis, hepatitis, COPD, kidney disease, arthritis, ulcers).

a. Etiology
b. Pathology
c. Diagnosis
d. Treatment
e. Prevention

1.22 Discuss research related to emerging diseases and disorders (such as: autism, VRSA, PTSD, Listeria, seasonal flu).

1.23 Describe biomedical therapies as they relate to the prevention, pathology, and treatment of disease.

a. Gene testing
b. Gene therapy
c. Human proteomics
d. Cloning
e. Stem cell research

1.3 Medical Mathematics

1.31 Demonstrate competency in basic math skills and mathematical conversions as they relate to healthcare.

a. Metric system (such as: centi, milli, kilo)
b. Mathematical (average, ratios, fractions, percentages, addition, subtraction, multiplication, division)
c. Conversions (height, weight/mass, length, volume, temperature, household measurements)

1.32 Demonstrate the ability to analyze diagrams, charts, graphs, and tables to interpret healthcare results.

1.33 Demonstrate use of the 24-hour clock/military time.

Foundation Standard 2: Communications

Demonstrate methods of delivering and obtaining information, while communicating effectively.

2.1 Concepts of Effective Communication

2.11 Model verbal and nonverbal communication.

2.12 Identify common barriers to communication.

a. Physical disabilities (aphasia, hearing loss, impaired vision)
b. Psychological barriers (attitudes, bias, prejudice, stereotyping)

2.13 Identify the differences between subjective and objective information.

2.14 Interpret elements of communication using basic sender-receiver-message-feedback model.

2.15 Practice speaking and active listening skills.

2.16 Modify communication to meet the needs of the patient/client and be appropriate to the situation.

2.2 Medical Terminology

2.21 Use common roots, prefixes, and suffixes to communicate information.

2.22 Interpret medical abbreviations to communicate information.

a. Common abbreviations
b. Joint Commission official "Do Not Use List"

2.3 Written Communication Skills

2.31 Utilize proper elements of written and electronic communication (spelling, grammar, and formatting).

2.32 Prepare examples of technical, informative, and creative writing.

Foundation Standard 3: Systems
Identify how key systems affect services performed and quality of care.

3.1 Healthcare Delivery Systems

3.11 Compare healthcare delivery systems.
   a. Non-profit and for profit (such as: hospitals, ambulatory facilities, long-term care facilities, home health, medical and dental offices, mental health services)
   b. Government (such as: CDC, FDA, WHO, OSHA, Public Health systems/Health Departments, Veteran's Administration)
   c. Non-profit (such as: March of Dimes, American Heart Association)

3.12 Describe the responsibilities of consumers within the healthcare system (such as: self-advocacy, patient compliance, provider and consumer obligations).

3.13 Assess the impact of emerging issues on healthcare delivery systems (such as: technology, epidemiology, bioethics, socioeconomics).

3.14 Discuss healthcare economics and common methods of payment for healthcare.
   a. Private health insurance (such as: Blue Cross, Affordable Care Act - ACA)
   b. Managed care (such as: HMOs, PPOs, medical home)
   c. Government programs (Medicare, Medicaid, Tricare, and Workers' Compensation)

Foundation Standard 4: Employability Skills
Utilize employability skills to enhance employment opportunities and job satisfaction.

4.1 Personal Traits of the Health Professional

4.11 Identify personal traits and attitudes desirable in a member of the career ready healthcare team.
   a. Acceptance of criticism
   b. Competence
   c. Dependability
   d. Discretion
   e. Empathy
   f. Enthusiasm
   g. Honesty
   h. Initiative
   i. Patience
   j. Responsibility
   k. Self-motivation
   l. Tact
   m. Team player
   n. Willingness to learn

4.12 Summarize professional standards as they apply to hygiene, dress, language, confidentiality and behavior.

4.2 Employability Skills

4.21 Apply employability skills in healthcare.
   a. Chain of command
   b. Correct grammar
   c. Decision making
   d. Flexible
   e. Initiative
   f. Integrity
   g. Loyalty

h. Positive attitude
i. Professional characteristics
j. Prompt and prepared
k. Responsibility
l. Scope of practice
m. Teamwork
n. Willing to learn

4.3 Career Decision-making

4.31 Research levels of education, credentialing requirements, and employment trends in health professions.

4.32 Distinguish differences among careers within health science pathways (diagnostic services, therapeutic services, health informatics, support services, or biotechnology research and development).

4.4 Employability Preparation

4.41 Develop components of a personal portfolio.

a. Letter of introduction
b. Resume
c. Sample Projects
d. Writing Sample
e. Work-based Learning Documentation
f. Oral Report
g. Service Learning/Community Service
h. Credentials
i. Technology Skills
j. Leadership Examples

4.42 Identify strategies for pursuing employment (social media, personal networking, job sites, internships).

Foundation Standard 5: Legal Responsibilities

Describe legal responsibilities, limitations, and implications on healthcare worker actions.

5.1 Legal Responsibilities and Implications

5.11 Analyze legal responsibilities and implications of criminal and civil law.

a. Malpractice
b. Negligence
c. Assault
d. Battery
e. Invasion of privacy
f. Abuse
g. Libel
h. Slander

5.2 Legal Practices

5.21 Apply standards for the safety, privacy and confidentiality of health information (HIPAA, privileged communication).

5.22 Describe advance directives.

5.23 Summarize the essential characteristics of a patient's basic rights within a healthcare setting.

5.24 Define informed consent.

5.25 Explain laws governing harassment and scope of practice.

Foundation Standard 6: Ethics

Understand accepted ethical practices with respect to cultural, social, and ethnic differences within the healthcare environment.

6.1 Ethical Practice

6.11 Differentiate between ethical and legal issues impacting healthcare.

6.12 Identify ethical issues and their implications related to healthcare (such as: organ donation, *in vitro* fertilization, euthanasia, scope of practice, ethics committee).

6.13 Utilize procedures for reporting activities and behaviors that affect the health, safety, and welfare of others (such as: incident report).

6.2 Cultural, Social, and Ethnic Diversity

6.21 Discuss religious and cultural values as they impact healthcare (such as: ethnicity, race, religion, gender).

6.22 Demonstrate respectful and empathetic treatment of ALL patients/clients (such as: customer service, patient satisfaction, civility).

Foundation Standard 7: Safety Practices

Identify existing and potential hazards to clients, co-workers, and self. Employ safe work practices and follow health and safety policies and procedures to prevent injury and illness.

7.1 Infection Control

7.11 Explain principles of infection control.

a. Chain of infection
b. Mode of transmission (direct, indirect, vectors, common vehicle [air, food, water], healthcare-associated infections [nosocomial], opportunistic)
c. Microorganisms (non-pathogenic, pathogenic, aerobic, anaerobic)
d. Classifications (bacteria, protozoa, fungi, viruses, parasites)

7.12 Differentiate methods of controlling the spread and growth of microorganisms.

a. Aseptic control (antisepsis, disinfection, sterilization, sterile technique)
b. Standard precautions
c. Isolation precautions
d. Blood borne pathogen precautions
e. Vaccinations

7.2 Personal Safety

7.21 Apply personal safety procedures based on Occupational Safety and Health Administration (OSHA) and Centers for Disease Control (CDC) regulations.

7.22 Demonstrate principles of body mechanics.

7.3 Environmental Safety

7.31 Apply safety techniques in the work environment.

a. Ergonomics
b. Safe operation of equipment
c. Patient/client safety measures (check area for safety)

7.4 Common Safety Hazards

7.41 Observe all safety standards related to the Occupational Exposure to Hazardous Chemicals Standard (Safety Data Sheets (SDSs)). (www.osha.gov)

7.42 Comply with safety signs, symbols, and labels.

7.5 Emergency Procedures and Protocols

7.51 Practice fire safety in a healthcare setting.

7.52 Apply principles of basic emergency response in natural disasters and other emergencies (safe location, contact emergency personnel, follow facility protocols).

Foundation Standard 8: Teamwork

Identify roles and responsibilities of individual members as part of the healthcare team.

8.1 Healthcare Teams

8.11 Evaluate roles and responsibilities of team members.

a. Examples of healthcare teams
b. Responsibilities of team members
c. Benefits of teamwork

8.12 Identify characteristics of effective teams.

a. Active participation
b. Commitment
c. Common goals
d. Cultural sensitivity
e. Flexibility
f. Open to feedback
g. Positive attitude
h. Reliability
i. Trust
j. Value individual contributions

8.2 Team Member Participation

8.21 Recognize methods for building positive team relationships (such as: mentorships and teambuilding).

8.22 Analyze attributes and attitudes of an effective leader.

a. Characteristics (interpersonal skills, focused on results, positive)
b. Types (autocratic, democratic, laissez faire)
c. Roles (sets vision, leads change, manages accountability)

8.23 Apply effective techniques for managing team conflict (negotiation, assertive communication, gather the facts, clear expectations, mediation).

Foundation Standard 9: Health Maintenance Practices

Differentiate between wellness and disease. Promote disease prevention and model healthy behaviors.

9.1 Healthy Behaviors

9.11 Promote behaviors of health and wellness (such as: nutrition, weight control, exercise, sleep habits).

9.12 Describe strategies for prevention of disease.

a. Routine physical exams
b. Medical, dental, and mental health screenings
c. Community health education outreach programs
d. Immunizations
e. Stress management
f. Avoid risky behaviors

9.13 Investigate complementary and alternative health practices as they relate to wellness and disease prevention (such as: Eastern medicine, holistic medicine, homeopathy, manipulative and natural therapies).

***Foundation Standard 10: Technical Skills**

Apply technical skills required for all career specialties and demonstrate skills and knowledge as appropriate.

10.1 Technical Skills

10.11 Apply procedures for measuring and recording vital signs including the normal ranges (temperature, pulse, respirations, blood pressure, pain).

10.12 Obtain training or certification in cardiopulmonary resuscitation (CPR), automated external defibrillator (AED), foreign body airway obstruction (FBAO) and first aid.

*Additional technical skills may be included in a program of study based on career specialties.

Foundation Standard 11: Information Technology Applications

Utilize and understand information technology applications common across health professions.

11.1 Key Principles of Health Information Systems

11.11 Identify types of data collected in Electronic Health Records/Electronic Medical Records (EHR or EMR) (such as: history and physical, medications, diagnostic tests, patient demographics).

11.12 Explore different types of health record data collection tools (such as: patient monitoring equipment, telemedicine, phone application, and medical wearable devices).

11.13 Identify the types and content of an EHR/EMR (such as: pharmacy, laboratory, radiology).

11.14 Create documentation in EHR/EMRs that reflect timeliness, completeness, and accuracy.

11.15 Adhere to information systems policies, procedures, and regulations as required by national, state, and local entities.

11.2 Privacy and Confidentiality of Health Information

11.21 Apply fundamentals of privacy and confidentiality policies and procedures (HIPAA).

11.22 Identify legal and regulatory requirements related to the use of personal health information (such as: Health Information Technology Act—HITECH Act, American Recovery and Reinvestment Act—ARRA).

11.23 Identify common policies and procedures for proper access, disclosure and protection of personal health information (such as: passwords, administrative safeguards, database security).

11.24 Describe consequences of inappropriate use of health data in terms of disciplinary action.

11.25 Understand the principle to correct inaccurate information/errors entered into an EHR/EMR (such as: adding, clarifying, and correcting information).

11.3 Basic Computer Skills

11.31 Apply basic computer concepts and terminology necessary to use computers and other mobile devices.

11.32 Demonstrate basic computer troubleshooting procedures (such as: restart, check power supply, refresh browser, check settings).

11.33 Demonstrate use of file organization and information storage.

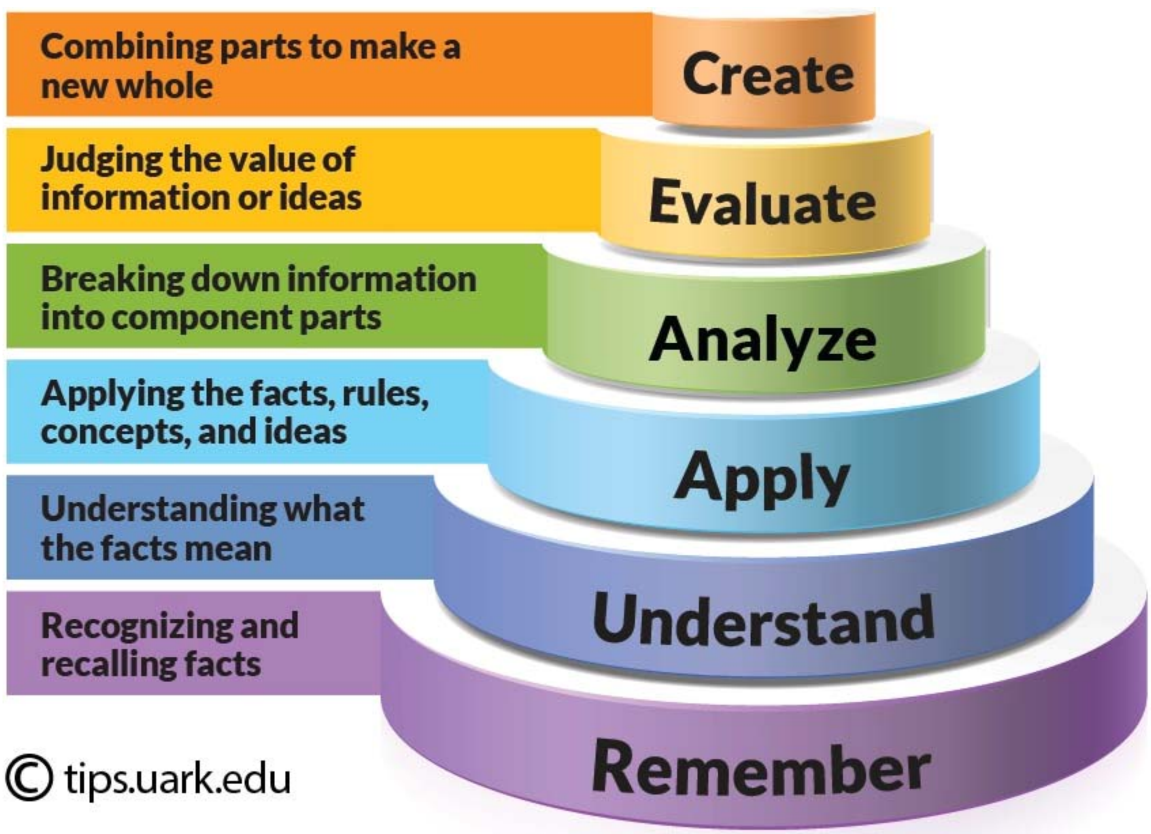
11.34 Identify uses of basic word processing, spreadsheet, and database applications.

11.35 Evaluate validity of web-based resources.

11.36 Demonstrate appropriate usage of email and social media in a work environment (such as: work-related communications, personal texting on own time, appropriate language and content, use full language sentences).

Appendix I: Bloom's Taxonomy

Bloom's Taxonomy is a set of hierarchical categories of cognitive thinking used by teachers to create lessons that encourage higher forms of thinking by their students, and to move away from predominantly rote learning (Bloom, 1956).



Bloom's Taxonomy of Cognitive Thinking. Adapted from "Using Bloom's Taxonomy to Write Effective Learning Objectives," by J. Shabatura, 2018, Best Practices, Course Design. Retrieved January 19, 2019, from https://tips.uark.edu/using-blooms-taxonomy/ Copyright 2018, tips.uark.edu.

Next Generation Science Standards (NGSS) were used as a framework for student performance and curriculum analysis in this study.

Three Dimensions of the *Next Generation Science Standards* (NGSS)

Scientific and Engineering Practices

Asking Questions and Defining Problems

A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works and which can be empirically tested.

Engineering questions clarify problems to determine criteria for successful solutions and identify constraints to solve problems about the designed world.

Both scientists and engineers also ask questions to clarify the ideas of others.

Planning and Carrying Out Investigations

Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters.

Engineering investigations identify the effectiveness, efficiency, and durability of designs under different conditions.

Analyzing and Interpreting Data

Scientific investigations produce data that must be analyzed in order to derive meaning. Because data patterns and trends are not always obvious, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Scientists identify sources of error in the investigations and calculate the degree of certainty in the results. Modern technology makes the collection of large data sets much easier, providing secondary sources for analysis.

Engineering investigations include analysis of data collected in the tests of designs. This allows comparison of different solutions and determines how well each meets specific design criteria—that is, which design best solves the problem within given constraints. Like scientists, engineers require a range of tools to identify patterns within data and interpret the results. Advances in science make analysis of proposed solutions more efficient and effective.

Developing and Using Models

A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations.

Modeling tools are used to develop questions, predictions and explanations; analyze and identify flaws in systems; and communicate ideas. Models are used to build and revise scientific explanations and proposed engineered systems. Measurements and observations are used to revise models and designs.

Constructing Explanations and Designing Solutions

The products of science are explanations and the products of engineering are solutions.

The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories.

The goal of engineering design is to find a systematic solution to problems that is based on scientific knowledge and models of the material world. Each proposed solution results from a process of balancing competing criteria of desired functions, technical feasibility, cost, safety, aesthetics, and compliance with legal requirements. The optimal choice depends on how well the proposed solutions meet criteria and constraints.

Engaging in Argument from Evidence

Argumentation is the process by which explanations and solutions are reached.

In science and engineering, reasoning and argument based on evidence are essential to identifying the best explanation for a natural phenomenon or the best solution to a design problem. Scientists and engineers use argumentation to listen to, compare, and evaluate competing ideas and methods based on merits.

Scientists and engineers engage in argumentation when investigating a phenomenon, testing a design solution, resolving questions about measurements, building data models, and using evidence to identify strengths and weaknesses of claims.

Using Mathematics and Computational Thinking

In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing simulations; statistically analyzing data; and recognizing, expressing, and applying quantitative relationships.

Mathematical and computational approaches enable scientists and engineers to predict the behavior of systems and test the validity of such predictions. Statistical methods are frequently used to identify significant patterns and establish correlational relationships.

Obtaining, Evaluating, and Communicating Information

Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity.

Communicating information and ideas can be done in multiple ways: using tables, diagrams, graphs, models, and equations as well as orally, in writing, and through extended discussions. Scientists and engineers employ multiple sources to acquire information that is used to evaluate the merit and validity of claims, methods, and designs.

NGSS@NSTA
STEM STARTS HERE
www.nsta.org/ngss

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Disciplinary Core Ideas in Physical Science	Disciplinary Core Ideas in Life Science	Disciplinary Core Ideas in Earth and Space Science	Disciplinary Core Ideas in Engineering, Technology, and the Application of Science
PS1: Matter and Its Interactions PS1.A: Structure and Properties of Matter PS1.B: Chemical Reactions PS1.C: Nuclear Processes **PS2: Motion and Stability: Forces and Interactions** PS2.A: Forces and Motion PS2.B: Types of Interactions PS2.C: Stability and Instability in Physical Systems **PS3: Energy** PS3.A: Definitions of Energy PS3.B: Conservation of Energy and Energy Transfer PS3.C: Relationship Between Energy and Forces PS3.D: Energy in Chemical Processes and Everyday Life **PS4: Waves and Their Applications in Technologies for Information Transfer** PS4.A: Wave Properties PS4.B: Electromagnetic Radiation PS4.C: Information Technologies and Instrumentation	**LS1: From Molecules to Organisms: Structures and Processes** LS1.A: Structure and Function LS1.B: Growth and Development of Organisms LS1.C: Organization for Matter and Energy Flow in Organisms LS1.D: Information Processing **LS2: Ecosystems: Interactions, Energy, and Dynamics** LS2.A: Interdependent Relationships in Ecosystems LS2.B: Cycles of Matter and Energy Transfer in Ecosystems LS2.C: Ecosystem Dynamics, Functioning, and Resilience LS2.D: Social Interactions and Group Behavior **LS3: Heredity: Inheritance and Variation of Traits** LS3.A: Inheritance of Traits LS3.B: Variation of Traits **LS4: Biological Evolution: Unity and Diversity** LS4.A: Evidence of Common Ancestry and Diversity LS4.B: Natural Selection LS4.C: Adaptation LS4.D: Biodiversity and Humans	**ESS1: Earth's Place in the Universe** ESS1.A: The Universe and Its Stars ESS1.B: Earth and the Solar System ESS1.C: The History of Planet Earth **ESS2: Earth's Systems** ESS2.A: Earth Materials and Systems ESS2.B: Plate Tectonics and Large-Scale System Interactions ESS2.C: The Roles of Water in Earth's Surface Processes ESS2.D: Weather and Climate ESS2.E: Biogeology **ESS3: Earth and Human Activity** ESS3.A: Natural Resources ESS3.B: Natural Hazards ESS3.C: Human Impacts on Earth Systems ESS3.D: Global Climate Change	**ETS1: Engineering Design** ETS1.A: Defining and Delimiting an Engineering Problem ETS1.B: Developing Possible Solutions ETS1.C: Optimizing the Design Solution **ETS2: Links Among Engineering, Technology, Science, and Society** ETS2.A: Interdependence of Science, Engineering, and Technology ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World

Crosscutting Concepts		
Patterns Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them. **Cause and Effect: Mechanism and Explanation** Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.	**Scale, Proportion, and Quantity** In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance. **Systems and System Models** Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.	**Energy and Matter: Flows, Cycles, and Conservation** Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations. **Structure and Function** The way in which an object or living thing is shaped and its substructure determine many of its properties and functions. **Stability and Change** For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

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(NGSS Lead States, 2013)

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