The Use of Hands-on Educational Pedagogy in A Standardized Science Curriculum

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THE USE OF HANDS-ON EDUCATIONAL PEDAGOGY IN A STANDARDIZED SCIENCE CURRICULUM

by

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ABSTRACT

Introduction

The purpose of this project is to implement an innovative, and engaging knowledge transfer pedagogy for 5th grade science students. This project utilized Stealth Learning, a learning pedagogy developed by Dr. James Rosser.[99,100,109,110] The program featured applied learning to develop skill sets in general and drone aviation, as well as minimally invasive surgery techniques. This was facilitated through the use of computers, table simulators, and drones.

Methodology

This project took standardized subject matter from the Florida Comprehensive Assessment Test (FCAT) and converted it into content featuring the Stealth approach. The section that was converted was the "Practice of Science and the Characteristics of Scientific Knowledge" portion of the FCAT. This program includes curriculum workbooks and worksheets, mini drones, scientifically-validated video games (Super Monkey Ball 2), Stealth Learning music-vocab videos (Animotos), surgical simulation skill drills (Bean Drop), and competitions material (Spelling Bee). A website was also made to allow students to review material at home. This program was administered with the assistance of healthcare and aviation professionals to provide a mentoring component. The program included an execution phase consisting of seven sessions, which took place for 45 minutes each during the Spring Semester (April 2016).

Preliminary Findings

There are preliminary results for this project, which must be explored further in future studies. This project first analyzed the Science FCAT scores for 72 students in the 5th grade. Of the 72 students in the class, 22 (30.5%) passed the exam. Eleven of the students were enrolled in our program and 54% (6 of 11) passed in comparison to twenty-six percent of the students that underwent standard preparation passed the exam.

Conclusion

Especially for minorities and the socioeconomically disadvantaged, student performance on state standard exams is one of the most pressing challenges faced in education today. This study suggests that a state standard-based 5th grade curriculum can be converted into an innovative brain-based lesson plan to enhance performance on state standard exams. This initial investigation offers some encouragement for others to further pursue this research.

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INTRODUCTION

Whether or not our current educational system encourages our youth to pursue long-term career paths may be called into question. For one, American high schools continue to be plagued by high dropout rates. In 2014, 6.5% of students dropped out of high school in the United States of America.[1] A solution for this dilemma cannot be simplified by increasing the performance levels on standardized tests; various studies have found standardized examinations to be discouraging and inaccurate measures of student performance. For instance, in their discussion of the Ontario Secondary School Literacy Test, researchers found that the standardized examination in question is disproportionately unfavorable to marginalized youth.[2,3] This is attributed at least in part to a phenomenon identified in a 2010 study, whereby students in possession of "cultural capital," or knowledge which individuals of more privileged backgrounds are predisposed to possess, receive favorable scores in comparison to their peers.[3] Therefore, there may be potential benefits to connect students to other educational platforms.

The modern student is not only connected to various media platforms on a multitude of devices, but they are in the process of preparing to engage with an increasingly diversified and fast-paced 21st century. For instance, a 2014 study indicated that 80% of teens 14-17 years old used their own smartphone.[4] That is not to say that all applications of technology in the classroom prove conducive to better learning: 64 percent of surveyed Advanced Placement instructors believe that new technologies prove more distracting than beneficial in the classroom.[5] Thus, new approaches more aligned with the 21st century student must be deployed, and these approaches must be aimed at enhancing students' educational experiences, rather than

detracting from them. It is no secret that the United States is far from a world leader in STEM (science, technology, engineering, math) performance; according to the Programme for International Student Assessment (PSA), one of the leading educational evaluators in the world, the U.S. ranks "an unimpressive" 38th out of 71 countries in math, and 24th in science.[5] This indicates inadequate performance by our educational system in the areas of STEM. Student involvement in STEM fields is extremely important, and not only because this pathway serves as a vehicle into a challenging and fulfilling career. Science-based skills training integrated into school curriculums has been demonstrated to bolster student performance in other academic areas, thereby encouraging the development of a variety of cognitive skills that will contribute to their eventual social productivity. For instance, a 2013 study found that robotics training led to notable improvements in science literacy skills of Hispanic students and mathematics and science literacy skills of African American students. The overall implication of these findings was that such learning environments would prove most beneficial "for students from underrepresented groups".[7] The lackluster rates at which American students are currently performing in STEM in comparison to the rest of the world undermines international perceptions of the United States. The damage goes both ways: the more interest in a field, the more promise of innovation it carries; without continuous innovation, the cutting-edge fields within STEM are undermined. For instance, one of the major challenges in healthcare could be its lack of applied experiential learning. The field of medicine has faced a deficit in workforce: a report from the AAMC cites a deficit of 13,900-25,900 physicians in 2017, and a predicted deficit of 40,800-104,900 by 2030.[8] This project will seek to design and develop an innovative approach to teaching science, conduct initial evaluations of student performance, and survey satisfaction with

teachers.

The overriding pedagogy of this project and its new approach is called Stealth Learning. Stealth Learning is an educational methodology that utilizes pop culture icons such as music, film, and video games to enhance engagement and increase knowledge and skill transfer. Brain based learning involves using strategic pedagogy to enhance knowledge and skill transfer. It does this by increasing levels of dopamine and oxytocin to accelerate neurotransmission, and mobilize unused neurons in the cerebellum. In essence, neuropathways are created and bound at an accelerated pace and this enhances the overall learning process.[99,100,109,110] The project will (1) convert the educational materials and subject matter goals of the Nature of Science section of the "Practice of Science and the Characteristics of Scientific Knowledge" portion of the FSA into the Stealth Learning format, (2) create a website that will allow for home study of these materials, (3) change all laboratory practicums to relate to an aviation theme featuring drones, (4) use surgical instruments/simulators and computerized/physical drone exercises to facilitate student development of surgical aviation piloting skills, and (5) mentor by having experts in medicine and drone aviation help execute the program.

LITERATURE REVIEW INTRODUCTION

Current State of Education

A 1997 study conducted by Labaree outlines the goals of the American educational system as follows: "democratic equality," "social efficiency," and, perhaps most relevant to this project, "social mobility," defined therein as preparing individuals "to compete for social positions".[9] Such an endeavor is hefty in both complexity and scale, particularly due to its bridging the gap between "what we hope society will become and what we think it really is".[9] Another study, conducted by Downey, Von Hippel and Hughes discusses the means by which schools are evaluated in realizing their goals, asserting that "achievement-based evaluation likely underestimates the effectiveness of schools," particularly those "serving disadvantaged populations".[10] In fact, a study conducted in 2016 among college-age students of color found that "the interaction between ethnic identity and school belonging was significantly associated with self-worth".[11] This is significant, because students' ethnicities have been found by multiple studies to correlate to their academic performance. This correlation is at least partially explained by "differentials in parental endowments," namely parental income and education level, as well as by the location in which students live (schools in lower income zones tend to see lower performance on standardized tests).[12]

Standardized examination has been a primary means of evaluating the performance of the American student for nearly half a century.[13] Throughout its deeply entrenched tenure in the American educational system, the process of standardized testing has been questioned by pupils and experts alike. For one, despite its ability to structure and evaluate general academic

performance, standardized testing does not accurately represent the entire scope of a student's academic ability.[14] This matters because it fails to take into account various personality traits that comprise the most dedicated and hardworking students, some of whom might fall through the gaps and sustain academic retention which may not accurately correlate to their work ethic. Furthermore, standardized examination has shown disproportionately favorable rates to systematically privileged students throughout history: "Black students are consistently less likely than white students to earn passing scores in all subject areas at each grade level," and this is particularly true for schools closely linked to "white financial advantage and black student segregation".[15] As such, this system undermines student achievement, particularly among students belonging to particular socio-economic groups, and its inability to assess individualized academic performance bolsters student discouragement.[15]

This project is primarily concerned about student discouragement. The aim of Stealth learning is not to eradicate standardized examinations, rather, it seeks to rectify many of the problems of an educational system focused on standardized student performance.[16] This project seeks to promote concepts which standardized testing has been said to discourage, particularly student engagement, collaboration, investment in learning (particularly across STEM fields), and sufficient confidence so students pursue educations in STEM.[16]

One of the problems with standardized testing involves cultural bias. Cultural bias is defined as "prejudice in a viewpoint that suggests preference for one culture".[17] There are different forms of cultural bias in testing, namely with accuracy and evaluating language acquisition. For instance, one study from Taylor and Lee argued that, based on certain cultural backgrounds, tests in America commonly measure a student's mastery of English rather than the

subject meant to be tested.[18] This can negatively impact minorities with different language backgrounds. For example, a math exam that includes instructions in English could mean that mastery of the language would once again be tested in another subject. Additionally, different cultures have various traditions and norms for what is right and wrong. Solano-Flores and Nelson- Barber found that a student's culture affects what the student perceived to be a correct or incorrect answer.[19] This makes true or false questions, and questions which rely more on inference, a greater challenge on standardized exams. According to the U.S. Census, the United States has a minority population of roughly 30%; therefore, the implications of standardized exams may affect an overwhelming number of students.[20]

Additionally, a study by Walpole found that students' exam scores may be affected by their perception of standardized tests as being "unfair".[21] Another major issue with respect to standardized testing is its universality. Students in low-income schools may not have access to supplemental study materials, and income has long been linked to academic performance.[22] This logic has prevailed for decades. In 1989, Taubman found that some children may be limited from achieving their optimal amount of education due their parents' income.[22] Though long-prevailing, the findings of this study are by no means obsolete; in 2011, Reardon noted that the educational (and performance) gap between high- and low-income students is continually widening. This study compared the incomes of families with students performing in the top 10th percentile on standardized examinations with those performing in the low 10th; the average yearly income of the former family was $160,000, while that of the latter was approximately $17,500. This study found that discrepancies become deeply ingrained into students' educational lives extremely early on; the socioeconomic differences in literacy and math skills were already

present before children enter kindergarten. Therefore, the earlier that strategies are implemented to rectify this discrepancy, the better.[23]

Why STEM Education

There is a documented deficiency in both the scope and quality of STEM education in the United States. In fact, the U.S. Department of Education lists an insufficient prevalence and distribution of instructors skilled in STEM subjects as a leading reason for the unimpressive rates of Americans who pursue advanced STEM education.[24] This is a self-perpetuating problem: few skilled STEM educators may reduce the likelihood that students will engage with science and math on a productive and encouraging level, which may lower the likelihood that these students will go on to pursue STEM careers, and the cycle continues. This is not conducive to a maximally productive economy. [26] According to the U.S. Department of Commerce, over the last decade, STEM jobs had a growth rate which was three times faster than non-STEM jobs.[25] A bustling STEM workforce is instrumental in the U.S's maintenance of its global leadership and competitive position as a global innovator.[26]

This emphasis on the importance of STEM education is disproportionate to the interest demonstrated by American students in science and math. Students are discouraged from actively pursuing studies in STEM due to prejudices against the subjects established early in their education. Hussain and Robinson attribute disinterest to the common notions among students that "STEM subjects are boring, too difficult or unwelcoming".[27] This evaluation corroborates the existing dialogue on the efficacy of standardized testing in bolstering student engagement, particularly in STEM fields: when certain aspects of their performance, like dedication and

improvement over time, are left out of performance evaluations, students are more likely to negatively attribute their exam scores to their own abilities.[28] In fact, the U.S. Department of Education lists "inadequate academic advising, career counseling, and institution support" as the primary reasons for lackluster student engagement with STEM career paths; although these deficiencies in student services may exist anywhere, they are disproportionately present in low-income schools.[29] This aforementioned study found that, of students entering college in pursuit of a Bachelor's degree in a STEM field, 57.8% of students in the lowest 25th percentile income bracket either ceased to pursue their education or switched majors to a non-STEM field.[29] Similarly, those whose parents obtained no more than a high school education either left school or their STEM majors at rates of 69.9%.[29] These problems must be rectified. Increased interest in STEM fields may be formulated when students are encouraged to be interested in the first place.

Remedial Students

If the goal of increased STEM student engagement is to maximize American performance in STEM fields on a global scale, then it begs the question: Why did our project focus on low-performing students? The U.S. Department of Education emphasizes the importance of ensuring that "all students have the chance to study and be inspired by" the STEM field.[30] It was with this line of thinking in mind that we developed and implemented the Stealth learning project. The term "low-performing" can be considered a subjective statement, as different characteristics must be taken into account.

This philosophy becomes important when considered with one particular point: that a student's income level serves as a predictor of achievement, and low income generally correlates

to low academic performance on standardized tests.[32] This indicates that low test scores are a more accurate measure of the opportunities (or lack thereof) afforded to students than of the quality of the students' abilities. For instance, a 2009 study conducted by the National Assessment of Educational Progress (NAEP) found that 71% of average-income high school students scored a "Basic" or better on their standardized examinations. Conversely, 44% of low-income students managed to score a "Basic" or better. This 27-point gap between income brackets speaks to the existing literature on the correlation between income and academic performance.[33] Furthermore, a study conducted by the American Educational Research Association concluded that effective and equitable science education considers students' prior knowledge, and experiences and articulates their relationships with the norms of school science in order to make science accessible for all students.[34] Therefore, it seemed both relevant and compelling to evaluate changes in performance, particularly in an area as rife with trepidation and insecurity as STEM, among students who are newly given access to educational enhancements which they would otherwise never have had access.

The Current State of Science Education

The urgency of the challenge posed by poor educational performance in the United States has not gone unnoticed. This country has been referred to as a "Dropout Nation".[35] One study found that nearly half of students said, "a major reason for dropping out was because of being bored".[35] It is interesting to note that 61% of the same group of students were passing when they decided to withdraw.[35] A 2015 report on science literacy in students receiving primary education found that "many students do not relate science to their own lives" and, as a result, demonstrate

low interest (and exhibit low performance) in science curriculums.[36] This research corroborates a 2006 study of the efficacy of student learning, which found that student critical thinking and performance is maximized when they are challenged to engage directly with their science study material.[37] Therefore, to correct the dilemma of lackluster STEM engagement amongst American students, the development of more engaging curriculums should be a high priority. Another major problem that is discussed in the 2015 report is students' common inability to see how scientific curriculums may be applicable to their everyday lives. In exit interviews of high school dropouts, 81% said their chances of completing high school would have improved if given opportunities to have their curriculum associated with real-world applied learning.[36] While curriculums are paramount to a student's success in class, high performance requires a considerable amount of out of class preparation. For instance, the National Center for Educational Statistics found that American students spend an average of 6.8 hours a week on homework strictly outside of the classroom.[38] The degree of motivation and self-discipline required to complete the increasingly individualized nature of homework assignments cannot be taught for simple repetition; rather, it must be fostered alongside genuine student interest in the subject matter. When asked about out-of-class prep, 7 out of 10 students said they "were not inspired to work hard".[35] To that end, it has been suggested that curriculums with incentive-based learning may help motivate students to complete their homework. In fact, the establishment of incentive-based learning has been cited as a leading motivator in improving homework completion rates and achievement in even the "poorest minority students in the lowest performing schools".[39] That is why it has been suggested that learning environments which take into account a student's socioeconomic status can foster more effective knowledge

transfer.[40]

It Can't Be Just About the Test

As a pathway to instituting educational reform, standardized examination has become a critical measurement of success. There are various advantages and disadvantages associated with such measures of educational achievement. Standardized tests can be beneficial when objectively comparing students because they help to eliminate bias and subjective grading. Multiple choice questions ensure that there is only one correct answer. Additionally, standardized test have lower administrative expenses, with as little as $5.81 per student per year.[41] Standardized tests also have the theoretical benefit of being non-discriminatory, as participation is not revoked or limited based on being a minority, impoverished, or being physically disabled. This kind of objectivity can be instrumental: a 2008 study published by the U.S. Department of Labor noted that, although affluent white males only comprise 35% of the U.S. population, between 95 and 97 percent of the people holding senior manager positions at Fortune 500 and Fortune 1000 companies are white males.[42] The absence of people of color at the highest rungs of the professional world is directly correlated to the educational opportunities afforded them; "education is essential to reaching one's human potential".[43] Other factors such as connections and socioeconomic status should also be taken into account when considering individuals in the professional world. An increased reliance on standardized testing means an increased reliance on narrowly-defined academic performance as a means to academic (and, eventually, professional) advancement, which could manifest itself into lower rates of economic mobility for students born into poverty. In 2011 the National Research Council found that test-based incentive programs

effects on achievement are small to none.[44] Additionally, many exams do not measure a holistic view of an individual, and frequently cause anxiety among students, which leads to a decrease in test performance.[45] Standardized tests may also change the dynamic of the classroom, and this may not be in the most beneficial manner. The Center for Public Education discussed the controversy of the impact of standardized testing in 2006, saying on one hand that tests are needed to allow "low-achieving students to catch up," while on the other hand admitting that standardized examinations also "shortchanges other students from learning important subjects".[46] All of the above has produced a public opinion that standardized tests emphasize "test-taking skills instead of gaining knowledge".[46] The key to moving forward is to present materials in a way that encourages mastery of the curriculum and that mastery must be connected to real world knowledge, skill and career applications. This notion is corroborated by Freeman who found that students in active learning classrooms had improved test scores, and were less likely to fail in comparison to students in traditional classrooms.[47] The test performance will then represent a reflection of the student's holistic understanding of the subject matter.

Big Problems in STEM

The STEM (science, technology, engineering, and math) field may be improved in the educational system. In fact, the U.S. Department of Congress reports the STEM unemployment rate rising from 1.8 to 2.5 percent between 2007 to 2015.[48] In comparison to other nations, the U.S. achievement in STEM falls behind many other countries.[49] The proportion of STEM to non-STEM bachelor degrees in the United States was considered one of the lowest.[50] Studies showed more than fifty-percent of college freshman switched out of their STEM majors, before they

reached graduation.[51] A few hindrances in acquiring a STEM degree may have to do with the time taken to complete the degree, and the cost associated. [52]

There are some other features of this STEM dilemma that should be highlighted. There is a significant gender gap in the STEM fields. According to a 2011 report by the US Department of Commerce, women held less than 25% of STEM jobs.[53] Similarly, women make up 50.8 percent of the American population, but just 28.4 percent of STEM workers.[54,111] There are different theories explaining this gender gap, including one theory called stereotype threat. It postulates that participation in the STEM and medicine fields is affected by students' perception of themselves, as well as to prevailing views, such as strong underrepresentation of women in STEM.[55] For instance, the *Harvard Business Review* lists five challenges said to be "pushing women out of STEM." These include having to prove themselves as worthy of the work they are doing repeatedly; having to walk a metaphorical "tightrope" between professional assertiveness and amicable femininity; questions about their "commitment and competence" that arise upon having children; feeling as though they are competing with other women for the one "woman spot" in a given field; and isolation from their peers.[56] Additionally, it was found that women with children suffered from a wage penalty of approximately 10% compared to women without children.[57] The poor representation of women in STEM and medicine may be combatted by reinforcing family-friendly workplaces that support a woman's choice to have a STEM or medical career and a family.[58]

Along with women, minority groups are also greatly outnumbered in STEM professions. White workers dominated STEM professions in 2011, occupying 70.8% of jobs in the fields, followed by Asian (14.5%), Hispanic (6.5%), Black (6.4%), and American Indian (0.4).[59] These

problems may be addressed by revamping the current educational model into one that better engages all students, since studies have found that students in "hands-on activities" scored higher on standardized tests in science.[60]

Another important issue is that educational curriculums should also include collaboration, which is a vital skill in the STEM field, as suggested by one study which found "collaborative learning" correlated with better grades.[61] Additionally, increasing both female and minority representation in the STEM professions may be assisted by hiring more female and minority faculty role models. This may be corroborated by evidence showing that female and minority students have a higher likelihood of pursuing a STEM major at institutions with a higher percentage of female/minority STEM graduate faculty.[62] This can help raise awareness, camaraderie, and relatability between individuals going through similar circumstances. Finally, mentoring is a vital element that may help bridge the gap between students and professionals, as one study found a positive effect when female students had like gender role models in their lives with STEM careers.[63]

A Growing Problem in Medicine

One of the greatest concerns of modern medicine, especially in the United States, is the current and impending shortage of physicians and surgeons. The expected deficiency of between 40,800- 104,900 physicians by 2030 does more than make the United States seem like a lackluster pioneer of science and math to the rest of the world. Less doctors may mean less efficacy in diagnosis in treatment, which comprises a problem for the American healthcare system.[64] Furthermore, there is a rural/urban imbalance that accentuates this deficiency in certain

regions. This has led to poor access in many communities.[65] With a growing and aging population and the struggle to recruit, educate, and retain physicians, this problem is likely to get worse in the future. According to the U.S. Department of Commerce, the population of those over 65, which is the age group that typically requires the most health care, is expected to shift from 13% in 2010 to 19% in 2030.[66] In the U.S., there are over 28.6 million insured citizens and this will exacerbate the shortage.[67] This ominous outlook for physicians is even more alarming for certain specialties such as surgery and primary care. In 2016, the AAMC predicted that by 2025 there would be a shortage of 61,000 to 94,700 physicians.[68]One particular field which is seeing a reduction is the primary care specialty. Primary care is expected to have a shortage of doctors in 2025 ranging from 14,900 to 35,600.[68] This increased need for doctors' leads to a dilemma; an urgency to rapidly recruit more providers to the work force.

To address this issue, many new medical programs have been established. In fact, the enrollment of first year medical students has risen from 16,433 (2002-2003) to 21,434 (2015-2016).[69] By 2020 there will be a total 31% increase in students since 2002.[69] Therefore, there is more of a demand from medical students to matriculate into medical school. However, as medical school positions increase, residency spots are growing at slower rate. This is especially true for general surgery, which according to the 2014 National Residency Match Program has 1,205 positions, compared to 1,057 in 2006, an increase of 148 spots.[70] In order to combat this dilemma it may be worthwhile to improve the lack of interest in the STEM field through early recruitment and exposure.

Lesson Plans

A 5th grade science curriculum was converted into subject manner based on the Nature of Science section of the FCAT. Different learning methods were considered when designing the lesson plans. Research has shown that hands-on learning experiences helped to enhance learning science curriculums; and that hands-on activities can be converted into an existing curriculum.[80] Also, according to Hmello-Silver's research, when subject manner is learned with problem-based learning, "students have the potential to develop life-long learning skills".[81] With this in mind, the traditional science workbook curriculum was converted into a curriculum utilizing a "hands-on" approach, which utilized a problem-based learning style. This approach would utilize innovative items, such as video games, drones, and surgical devices. The premise of using this approach would be to keep students involved; the efficacy of this was noted in one independent observation, during which teachers who used hands-on learning noted that their students generally stayed on task.[82] For all of these, a traditional science workbook was converted to an interactive experience for instructing students about science.

Along with the hands-on approach incorporated in this curriculum, there was also an emphasis on working in centers. This is because previous research found that students in cooperative learning had greater retention rates and maximized their long-term retention.[83] One study found that students who worked in a group versus those who worked independently were able to tackle complex problems to a considerably higher degree.[84] For these reasons, students were put into groups of three to four and rotated around three centers. This was to help foster higher-order thinking, and retention of knowledge. Previous research also found that working in groups helped students develop professional world skill-sets.[85] Our program provided many real-

world applications, such as using real drones and surgical equipment. The benefits of knowledge transfer and professional experiences help to solidify the use of a group-centered format.

Since the purpose of the project was to ensure proper preparation for the FSA, certain exam preparation materials were incorporated into the curriculum. However, the question remained about whether to use multiple choice questions or essay-formatted questions. Researchers have found that multiple-choice questions required less effort and were easier in comparison to essay questions, and that "students had more favorable attitudes towards multiple choice exams".[86,87] For these reasons, multiple choice questions were featured in the lesson plans.

Heikkila and Tiipanna studied elementary students' memory performance of different elementary students. Their results found that "congruent multisensory experiences during encoding" can cause an improvement in memory acquisition in the students.[88] this study can be further supported by another research report which demonstrated that multisensory-protocols were more effective for learning vs. unisensory-protocols.[89] Therefore, lesson plans were structured to auditory, visual, and tactic learning styles. Additionally, the lesson plan questions were adjusted to include the centers which were being discussed that day. The day also ended with the students having a verbal discussion about what they had accomplished that day. In this way, the lessons plans marked a stark contrast between the usual workbook protocols.

Animotos

There were specific Animoto videos and lesson plans made to facilitate hands-on

learning. These instructional tools were individually made to go over key vocabulary words and benchmarks. These Animotos were built to enhance student engagement through: repetition, auditory representation and visual representation.

Animoto is an online video application that allows users to create professional-quality videos.[71] Our team created customized videos to further emphasize and reinforce key information from the Nature of Science Curriculum. Previous studies have shown that videos can be useful for teaching. In fact, scholars have developed teaching typologies to show the significance of utilizing a video pedagogy.[72] The Animotos created for this interactive project included written scripts with engaging characteristics, including repetition, music, movements, and visuals. The benefits of repetition have been shown to facilitate children's vocabulary retention by reinforcing sentence structure.[73] One study even found that there is a significant benefit in expanding intervals of repetition. [74] Thus, in the Animotos created for this project, vocabulary words and skill sets were repeated at least three times and a website was created so students could expand the time intervals spent watching the Animotos.

One study found that, based on home listening practices, teachers "might find it beneficial to present familiar music".[75] A previous longitudinal study found that, after one year, the students who received a music-incorporated training program had significantly better recall and learning for verbal information.[76] Furthermore, Weigmann found that music can cause the activation of the dopamine-reward center of the brain.[77] Therefore, familiar music was incorporated into the Animotos to further engagement and benefits on verbal memory.

Visual representation was an important element of the Animotos as well. Previous

research showed that visual representations were effective in increasing a student's higher order thinking.[78] This also goes along with research from Levie and Lentz who found that images with text-redundant information facilitate learning new information.[79] This is why repetition, music, movement and visuals were utilized to develop Animotos.

In order to further engage the students, to watch the Animotos, friendly competitions were incorporated into the curriculum. These competitions included spelling bees, in which prizes were given out during the final days.

How Our Project Will Address This Problem

This project uses innovative approaches to address many of the issues that have been previously discussed. It studies whether a fifth grade state standardized curriculum can be converted to an engaging brain-based learning pedagogy (Stealth Learning) that utilizes pop culture staples such as music, Animotos, and validated video games to assist in preparation for the Florida Comprehensive Assessment Test (FCAT), which has now become the Florida Standards Assessments (FSA). The featured content is the Nature of Science section of "Practice of Science and the Characteristics of Scientific Knowledge." In addition, this new curriculum will incorporate into lesson plans early exposure to STEM and medical-related careers, focusing primarily on engineering, aviation, drones and minimally invasive surgery through robotics. This project represents an initial development of new educational tools seeking to fulfill the short-term goals of improving engagement, knowledge transfer, and test scores, all the while contributing towards the long-term goal of bolstering interest in STEM and medicine related careers.

METHODOLOGY

Participants:

A group of eleven fifth-grade students at a Title 1 elementary school were exposed to the program.[90] The school is located in an impoverished area with a high crime rate, 98% minority population and lack of involvement from the parents.[90] The students were chosen because of their need for remedial instruction.[90]

Materials

- Curriculum workbooks/worksheets
- Mini drones
- Scientifically validated knowledge and skill-transferring video game (Super Monkey Ball 2)
- Stealth Learning music-vocab videos
- Vimeo website to allow student to view Stealth videos at home
- Surgical simulation skill drills (Pea Drop)
- Aviation and drone skill-development center (simulator and mini-drones)
- Competitions material (spelling bee)

Methodology

This project features several innovative pedagogies blended into a cohesive knowledge

transfer unit. They include Stealth Leaning, Top Gun surgical training, validated video games, general and drone aviation training, and a customized website. The purpose of the project is to create an enhanced curriculum to help the students comprehend and pass the Science portion of the Florida Comprehensive Assessment Test (FCAT). The 5th grade FCAT is cumulative so it includes benchmarks from 3rd, 4th, and 5th grade. The section chosen for this program was the Nature of Science section utilizing the "Practice of Science and the Characteristics of Scientific Knowledge" workbook.

Profile of the Students' Academic Environment

According to data released from the Florida Department of Statistics the students in this program attended a Title 1 (free lunch) school, with 98% minority level, and 100% of the students being in an "economically disadvantaged state."[91] Additionally, in the 2014-2015 year the school had received an overall "D" grade.[91] FCAT scores from 2014-15 for the school involved with this project showed that out of the three FCAT categories (English, mathematics, and science), the science FCAT scores were the lowest of the three. The English Language Arts had a passing rate of 37%, mathematics was 49% and the science section was 18%.[92] The average statewide passing rate for science was 26% in 2003, 51% in 2011, and 56% in 2015-2016.[93]

The Science portion of the FCAT is broken down into four categories: Nature of Science, Earth and Space Science, Physical Science and Life Science. The exam is taken in early May and is divided into two sections that are 80 minutes long. The exam is multiple choice and consists of different types of questions including graphics, passage-based, and discrete-style questions. The

exam is also broken down into low, medium and high-complexity type questions; with 60-80% of the questions being in the medium to high complexity group.[94]

The subject matter of this program is the Nature of Science section and it is scored on a ten-point scale. This section was chosen because it represents one fourth of the science FCAT exam. The benchmarks are coded with the first two letters corresponding to the subject matter (SC), followed by numerals corresponding to grade level (5), the third position is the Body of Knowledge (N) benchmark, the fourth position in the Big Idea benchmark (1.1, 2.1, 2.2).[94] The three benchmarks are: SC.5.N.1.1. (analyzing data, defining problem, and evaluating procedure), SC.5.N.2.1 (Distinguishing between observations and opinions, and importance of observations), and SC.5.N.2.2 (Importance of replication, and reasons for differences in data).[95] The overall FCAT science score is graded between 1 (lowest) to 5 (highest), with a score of a 3 or above considered to be passing.[96]

Stealth Learning Enhanced Curriculum

The pedagogy utilized in this project is Stealth Learning. Stealth Learning is a brain-based educational methodology that encourages engagement and facilitates knowledge and skill transfer. It creates an environment that enhances the release of important neurotransmitters within the brain. Stealth Learning based curriculums are filled with positive omnipresent competition with performance metrics, music, and pop culture, such as music, film, and video games.[16] Stealth evolved from the research efforts of James C. Rosser, Jr, MD FACS. Dr. Rosser has spent years training doctors in minimally invasive surgery. This most difficult of surgical techniques poses a serious knowledge and skill challenge for surgeons.[16] Stealth Learning tries

enables surgeons to gain proficiency in certain minimally invasive surgical techniques. After the pedagogy had achieved extensive scientific vetting through publications in medicine, Rosser began to apply it to general education.[99,100,109,110] Stealth Learning does not change what is taught in a curriculum; it enhances its execution and aims to provides engaging, customized knowledge transfer, while establishing skill sets needed for career choices in STEM.[16]

Top Gun Surgeon Training Program

The Top Gun Surgeon Laparoscopic Skills and Suturing Program is the STEM mentoring component of Stealth Learning. It provides an engaging real-world focus that doubles as a conduit for exploring the scientific method. Top Gun was developed to provide an efficient and effective skill acquisition platform for minimally invasive surgery. It partners with a training methodology that forms the core curriculum of the historic Navy Top Gun school for fighter pilots. The Stealth Top Gun program involves different exercises including Bean Drop, Rope Pass, Triangle Transfer, and intracorporeal suturing.[97] The "Bean Drop" exercise was integrated into this project. This exercise requires students to use their non-dominant hand to grasp and transfer a bean into a metal cylinder with a hole at the top. In order for the exercise to be completed, ten beans must be passed through the aperture. The drill is conducted inside a simulator of the abdomen with an electronic proctor. It records the number of errors and the time it takes to complete the task. The students work in dyads supervised by a medical professional. While one student is performing the exercise, the other student is using a camera to guide and direct all activity. They are dependent on each other to score well. This helps build teamwork and facilitates important scientific method activities, such as collecting data and making tables

and graphs.

Validated Video Games

Video games have long been scientifically validated to be useful in knowledge and skill transfer in minimally invasive surgery.[98,99,100] This project utilized one of the validated video games, Super Monkey Ball (SMB). It requires the student to make contact with designated items while driving a spherical ball around an undulating course. It increases non-dominant hand dexterity, while also improving visual spatial compensation and targeting skills. Performance is determined by measuring the time needed to complete the course while also subtracting time for any errors received.

Drone and General Aviation

A drone and aviation based exercise was incorporated into the Stealth Learning curriculum. Currently, drones are projected to be a $127 billion industry by 2020.[101] Drones are remote-controlled aerial vehicles that can be used for a variety of tasks.[102] In this program, palm-sized Teeny Drones™ were used. Teeny drones are miniature 6-axis quadcopters. They are some of the smallest drones on the market, and are only 1.5 by 1.5 inches long, and weigh only 13.7 grams.[103] These mini drones come with a full size remote that can range up to 2.4 Ghz, and allows you to move the drone in any direction including a flip button.[103] The drones provided a fertile and engaging platform to conduct scientific method experiments. They were used to evaluate flight time degradation with increasing amount of weight to be lifted. Over the course of the program, students used the computer-based RealFlight simulator to establish their flight skills

before proceeding to flying the drone themselves. RealFlight simulator is an remote control flight simulator which can be used to emulate flight/controller conditions when flying a drone.[104] This simulator has a wired transmitter interface, and provides the user with 3-D depth perception for flying a drone. It has realistic physics and graphics, along with 40 flying sites.[104] This portion of the program was closely supervised by aviation mentors.

Project Design and Execution

The execution of this project was separated into a planning/development phase, and an execution phase. The planning and development phase was completed over 2.5 months and featured items that were described above. The execution phase included seven sessions which took place for 45 minutes each during the spring semester of 2016. The emphasis was on dynamic re-teaching using the Stealth method rather than just going through the traditional remedial worksheets.

Planning/development Phase

The curriculum was developed based on the 5th grade P-SELL (Promoting Science among English Language Learners) science book containing the Florida Next Generation Sunshine State standards. Educational goals were established based on the designated materials, and the main concepts were divided among ten Animoto videos. These Animoto videos were paired with interactive learning activities and skills centers with the goal of immersing the students in the learning material using different learning styles (visual, aural, verbal, physical, logical, and social). In addition to the Animoto videos, the assessment questions from the P-

SELL book were rewritten to be aligned with the modified curriculum.

Execution Phase

The curriculum was divided into seven sessions that took place during school with a group of eleven students who were selected by the school administration based on after-school availability and parental consent. The sessions took place throughout the month of April 2016 and were each forty-five minutes long. For each session, the students were divided into three groups. Each group rotated through centers in a classroom that was equipped with a video projector and sound system. Medical and aviation mentors, along with two middle school science coaches, led the center. In general, the science coaches led the Animoto sessions, while mentors led the skill and experiment sessions. To provide an incentive, students were rewarded with ribbons for active participation in each of the centers. In addition, the students were provided links to a special website to view the Animoto videos at home or on computers at school. A special key word was presented at the end of each Animoto video to provide the children with incentives to review the material and to earn extra ribbons.

The first session was held on Thursday, April 7, 2016, and started with a ten-minute introduction to explain objectives, introduce the students to the educators/mentors, and to get them excited about the sessions. The rest of the time was divided into three ten-minute centers: an Animoto center and two skill centers. The Animoto center consisted of showing “What do Scientists do?” followed by a discussion led by the educator and a second viewing of the Animoto. The first skill activity was a video game, Super Monkey Ball, consisted of students playing the video game while taking turns in the following roles: timer, player, and recorder. The

second skill activity, Bean Drop, consisted of students learning the activity and rotating through the following roles: camera operator, participant, and timer/scorekeeper.

The second session was on held Tuesday, April 12, 2016, and started with a ten-minute introduction to the drones and drone simulators. The rest of the time was divided into three ten-minute centers. The Animoto center consisted of showing the “Observation” and “Qualitative vs. Quantitative” video. There was also an interactive workbook activity led by the educator. The second center leveraged the Super Monkey Ball video game activity with the focus being making qualitative and quantitative observations. The third center repeated the Bean drop activity in first session, and similarly, focused on making qualitative and quantitative observations.

The third session was held on Wednesday, April 13, 2016, and consisted of three fifteen-minute centers. This session was the first time the drones and drone simulators were introduced to the students. The Animoto center showed “Inference and Predictions” Animoto and presented a workbook activity. There were two skill activities. The first was the Hover Buzz in which students practiced their observation skills using the Teeny Drone. In the second skill activity, students used the simulator and practiced take-off and landing. The students were paired into groups of two or three with one student participating as player, and the other students acting as observers.

The fourth session was held on Friday, April 15, 2016, and consisted of three fifteen-minute centers. The Animoto center showed the “How do Scientists Understand and Explain the Natural World” and “Experiments” video with an assigned workbook activity. In another center, the students performed the Bean drop activity with the dominant hand. Time to complete the task

was recorded, and it was compared to previous data using their non-dominant hand. The third center consisted of reviewing workbook practice assessment questions and answers with the students.

The fifth session was held on Tuesday, April 19, 2016, and consisted of three fifteen-minute centers. The Animoto center focused on “Inquiry Framework and Doing Good Scientific Inquiry”, and completing the assigned workbook activity. The drone simulator center was repeated; however, during this session, the educator guided students through a scientific inquiry and experiment design based on the drone activity. Also, a spelling and vocabulary review was conducted using a “spelling bee” format.

The sixth session was held on Friday, April 22, 2016, and consisted of three fifteen-minute centers. The Animoto center consisted of showing the “Variables” and the “Control Group” videos, and also completing the assigned workbook activity. The second center consisted of reviewing the remaining practice assessment questions with the students and working through the answers as a group. The third center consisted of the students completing the Drone Lift Experiment guided by an educator and aviation expert. The students were also tasked to practice going through the entire inquiry framework process within the context of an experiment.

The seventh session was held on Tuesday, April 26, 2016, and was the final session. It consisted of the Animoto final quiz, which allowed students to earn extra ribbons if their answers to the quiz confirmed that they watched the videos on their own time. The second part of the session consisted of the grand finale spelling bee. The students had the opportunity to show off their spelling and understanding of curriculum vocabulary words that were emphasized

throughout the previous sessions.

After the seven sessions were completed, a separate wrap-up day was conducted. This day included a chance for the students to interact and discuss career opportunities in the aviation and medical field. Additionally, this final day included prizes, drawings, and other special recognitions to encourage the students to consider STEM careers and to continue to try to excel in science.

PRELIMINARY OUTCOMES

There were some preliminary results when analyzing FCAT exam scores. The results for this project analyzed the Science FCAT scores for 72 students in the 5th grade. Of the 72 students in the class, 22 (30.5%) passed the exam. Eleven of the students were enrolled in our program and 54% (6 of 11) passed. Twenty-six percent of the students that underwent standard preparation passed the exam. Twenty-seven percent (almost a third) of the passing students were from the program, even though this group only represented 15% of the entire class.

The students who participated in the program were remedial students, and it is thus impressive that they scored higher. The problem in this study is that it lacks statistical significance. Our program only had access to the science scores, and focused on science portion of the FSA exam.

DISCUSSION OF PRELIMINARY OUTCOMES

This investigation suggests that a brain based learning pedagogy with validated pop culture educational assets along with career skill building and mentoring is an alternative that may promote enhanced performance on a state standards exam in science. The average state standard performance of students on this portion is a 56% passing rate.[93] Only 26% (16 of 61) of the students who solely used the standard preparation approach for the Nature of Science section passed the science FCAT. Whereas, 54% (6 of 11) of the students who participated in the additional enhanced program passed the exam. This was impressive because students had a very limited exposure to the program. Often, there is a concern about selection bias in studies such as this but the students who were selected for the program were all remedial students. Additionally, it should be noted that the student body as a whole featured substandard performance. Even though the enhanced group performed only slightly better. Further study with increased numbers of students and extended exposure time to the enhanced learning sessions could yield a more clear advantage. Further studies should be conducted with a larger sample size to increase the statistical power.

CONCLUSION

The educational tools created through this project offer some encouragement for others to extend this curriculum-style; especially for minorities and the socioeconomically disadvantaged, student performance on state standard exams is one of the most pressing challenges faced in education today. This does not speak to a lack of ability amongst low-income or minority students. Rather, it seeks to acknowledge the systemic disadvantages faced by children of these demographics as they pursue educations, thereby rectifying the scopes of these issues and inciting increased participation in STEM-related educational fields. In fact, if this project suggests anything, it is that academic enthusiasm and excellence may be achieved, regardless of student demographics, through activities intended to maximize both creativity and engagement.

We predicted that the curriculum could be converted and instituted in the classroom's setting while improving test scores and achieving high satisfaction with students and teachers. The curriculum was converted successfully into a classroom setting. Future analysis (with a larger sample size) will be done to test the curriculum's effect on exam scores.

As was discussed in previous sections, various methods were undertaken to this end: this included the incorporation of Animotos and upbeat popular music into daily lessons and activities; and the integration of friendly competition amongst the students in order to make their undertakings in the classroom goal-oriented. There was also an establishment of different learning centers within the classroom to foster diversity in learning mechanisms, thereby prolonging and expanding student interest in the subject matter.

In the future, we hope to continue to enhance the quality of the program. This means making more Animoto videos for additional topics covered on the exam. As of right now, we

only focused on the science portion of the FCAT. However, prospective projects may have additional academic subjects become incorporated into their curriculum. The incorporation of additional subjects would require expansion of the Animotos, and lesson plans to the corresponding subject matter. The program plans to expand with different schools across the East coast. Hopefully, the expansion across varying schools will allow a level of communication between the schools and instructors involved. Educationally, the program will continue to stay updated to the state's benchmarks. We plan to have constant monitoring and satisfaction queries conducted in order collect qualitative data on the classroom experience for the teachers and students. The teacher and mentors involved in the program will be thoroughly trained on the protocol and their role in the program. The students will also be given resources at the end of the program to continue to be involved in the Stealth Learning program (such as a mentor in the future). Also, individual teacher involvement and recommendations will help to modify the curriculum to be customizable for each classroom.

The innovative approach of Stealth Learning may offer some hope of addressing the issue of disproportionate performance among minority and low-income students on standardized tests. It may also provide a feasible alternative to standardized tests in measuring, inciting, and evaluating student academic performance. Even with its occasional drawbacks, this program offers a promising alternative to standardized examination and the system of memorization-regurgitation which it encourages, thereby ushering in a series of possibilities for interactivity and excellence among students who may otherwise not have had them.

Further Directions

This program can be implemented and expanded in scale. First, there must be consideration given to classroom versus after school enrichment applications. Execution of both these venue options are different. Changes to classroom curriculum flow are difficult to implement. On the other hand, after school enrichment programs, which have well-established venues and funding sources, may offer an easier entry trajectory. Previous studies have suggested benefits to STEM learning in afterschool care can be: improved attitude of STEM, knowledge transfer, and a higher likelihood to pursue STEM careers.[105]

A potentially problem may be concerns involving training and organization of the program. First, there two "train the trainer" initiatives can be undertaken, one for the teachers and one for the helpers. These two training elements need to be coordinated with a standard program to ensure program delivery consistency. Recruitment and empowerment of the program helpers is key to the success of the program. Their training would not only involve a paid position for assisting in the execution of the program, but skills would be developed that could help in securing the helpers with 21st century job offers. For example, the helpers would develop surgical skills that could lead to jobs in the STEM field. In addition, they could take advantage of the exploding drone industry, which is slated to be a $127 billion business in 2020.[106] This may provide opportunities in the fields of border control, search and rescue, bridge inspections, and more. Drones may also provide an advantage over current methods of data collection.[107] Some students may use this as motivation to seek a career in full-scale aviation. Other job opportunities that can spin off from the drone applications include aerial photography and multimedia development.

Finally, there are two other obstacles that one may perceive as barriers to widespread implementation. One is the cost of the equipment; however, the drone simulators and miniature drones are very cost effective with the main cost being a laptop computer. The validated video game and game platform are early generation offerings that are also inexpensive and widely available. Cost concerns are mainly limited to the surgical simulation equipment. Fortunately, there have been recent developments of cost effective non-medical grade surgical simulator platforms that provide a similar impression of realism via an iPad app.

A considerable challenge to mass implementation of this program is the participation of mentors. Mentorship can be a strategic element to the success of a career program. One study published in *Science Daily*, tracked the mentoring effects of over a 1,000 participants in Big Brothers Big Sisters agencies, and found that children with mentors are significantly more confident in their academics.[108] The mentors in this study were directly involved with every step of the students' engagement with it. With the expansion of the program might come challenges in ensuring that all students have the same access to expert mentors. This problem can be rectified by "cybermentoring." The use of cost effective applications such as Zoom and Skype, can bring mentors to the students. This will help in mentor recruitment and retention with travel being eliminated from the participation equation.

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