

in a secondary high school classroom

Nigel Jagoo<sup>1</sup>, Anna Pyayt<sup>2</sup>, Howard Kaplan<sup>3</sup>

<sup>1</sup>Leto High School/Hillsborough Community College

<sup>2</sup>College of Chemical and Biomedical Engineering, University of South Florida

<sup>3</sup>Advanced Visualization Center, University of South Florida

<sup>1</sup>nigeljagoo@gmail.com, <sup>2</sup>pyayt@usf.edu, <sup>3</sup>howardkaplan@mail.usf.edu

**Abstract**

The state of Florida adopted new science standards in 2010 in an effort to help students remain competitive on a global market. Data presented in 2008 indicated that most countries out performed students in the U.S on international standardized tests. Newly adopted standards were introduced in Florida - 'Next Generation Sunshine State Standards (NGSSS) - and included less concepts to be learned but more depth and focus on higher order thinking. To assess students on these new standards, the Biology End of Course (EOC) exam was introduced in 2012. This exam was divided into 6 major parts: 1:Nature of Science & Ecology; 2:Energetics and Genetics; 3: Molecular Biology; 4: Evolution & Classification; 5: Plants & Reproduction; 6: Body Systems. Hillsborough County is the 3rd largest school district in Florida with 9 high schools which are 'Title 1' (high % of students from low-income families). In analyzing data from the past 4 years, the lowest performing schools on the Biology EOC Exam were Title 1 schools with the lowest performing unit consistently being 'Evolution & Classification' (<16% pass rate). We believe that by using 3D technology coupled with effective pedagogy in introducing new evolutionary concepts, students at Title 1 schools would achieve a pass rate of >16% on standardized tests in 'Evolution & Classification' questions. Preliminary data shows an increase of 58% (p < 0.05) in student achievement when instruction was coupled with the use of 3D printing.

**Background**

The state of Florida adopted new science standards in 2010 in an effort to help students remain competitive on a global market. Data presented in 2008 indicated that most countries out performed students in the U.S on international standardized tests. Because of this, newly adopted standards were introduced in Florida - 'Next Generation Sunshine State Standards (NGSSS) - and included less concepts to be learned but more depth and focus on higher order thinking. To assess students on these new standards, the Biology End of Course (EOC) exam was introduced in 2012. This exam was divided into 6 major parts: 1: Nature of Science & Ecology; 2: Energetics and Genetics; 3: Molecular Biology; 4: Evolution & Classification; 5: Plants & Reproduction; 6: Body Systems. Hillsborough County is the 3rd largest school district in Florida with 9 high schools which are 'Title 1' (high % of students from low-income families). Many concepts in the Hillsborough County Public Schools biology curriculum require students to employ their spatial visualization processes in order to relate spatial relationships to function. One such unit is the 'Evolution & Classification' unit which many students struggle with, according to EOC data. Within this unit students are expected to understand how structures have changed over time in relation to environmental pressures. Students encounter words such as 'intrude' or 'protrude' which they tend to have difficulty visualizing when presented with only 2D representations. Previous studies involving 3D printing in classrooms showed teachers becoming frustrated with the utilization of the 3D printers. Throughout the country, schools have begun to buy 3D printers and create MakerSpaces. To advance education in STEM classes, teachers need to be able to learn and use this technology easily. However, the tools and procedures needed for 3D printing are too varied and very complex, and consequently, teachers are not certain as to which 3D printers are preferred and how best to implement the technology.

Part of the problem lies in the design challenges of a 3D model for a 3D printer, which can significantly impede broad implementation and usefulness of 3D printing and 3D modeling in high school education . Teachers and students have to use one piece of software for sketching their designs, another one for conversion for printing, and a final one for communication with the 3D printer. In this design, each piece of software takes significant time to learn and as a result, the implementation becomes a challenging and overwhelming process for users. Another challenge in the high school classroom lies with involving appropriate pedagogy with the use of 3D printing. Many teachers tend to use new technology as a means of assessment rather than as a tool to enhance learning. Hillsborough County, within recent years, has shifted the focus of student learning in a science classroom to one that is 'inquiry based'. The use of 3D printing, therefore, must be embedded within an inquiry based lesson to achieve maximum results of enhancing student learning.

**Objectives**

- Create a lesson which incorporates a phone 'app', 3D printers, inquiry based teaching strategies and level 3 EOC style questions
- Implement 3D printing in 5 Title 1 schools in Hillsborough County to enhance student test scores in 'Evolution & Classification' questions (level 3)
- Allow teachers and students to use a cyber-tool called ""EASE 3D"" which would permit printing of 3D models from one application
- Evaluate student test scores before and after the use of the 3D technology

**Approach**

Preliminary Data:

- The devised lesson plan was carried out using freshman college students at 'The Art Institute of Tampa Bay'. A class of 28 students were divided into two groups –Group 1 was used as the control and not given the 3D lesson while group 2 was given the proposed lesson plan with 3D printing. Figure 1 shows the results. The lesson plan consisted of a 'Pre-Test', Introductory video of 'The tree of Life', group discussion on natural selection, power point on structural adaptations, 3D design and printing of human skulls based on varying environments (includes poster board with 'Analysis', 'Justification' & 'Reflection' Figure 5), Group carousel critique, and 'Post-Test'. Data from preliminary data was presented to The College of Education at USF for grant approval.

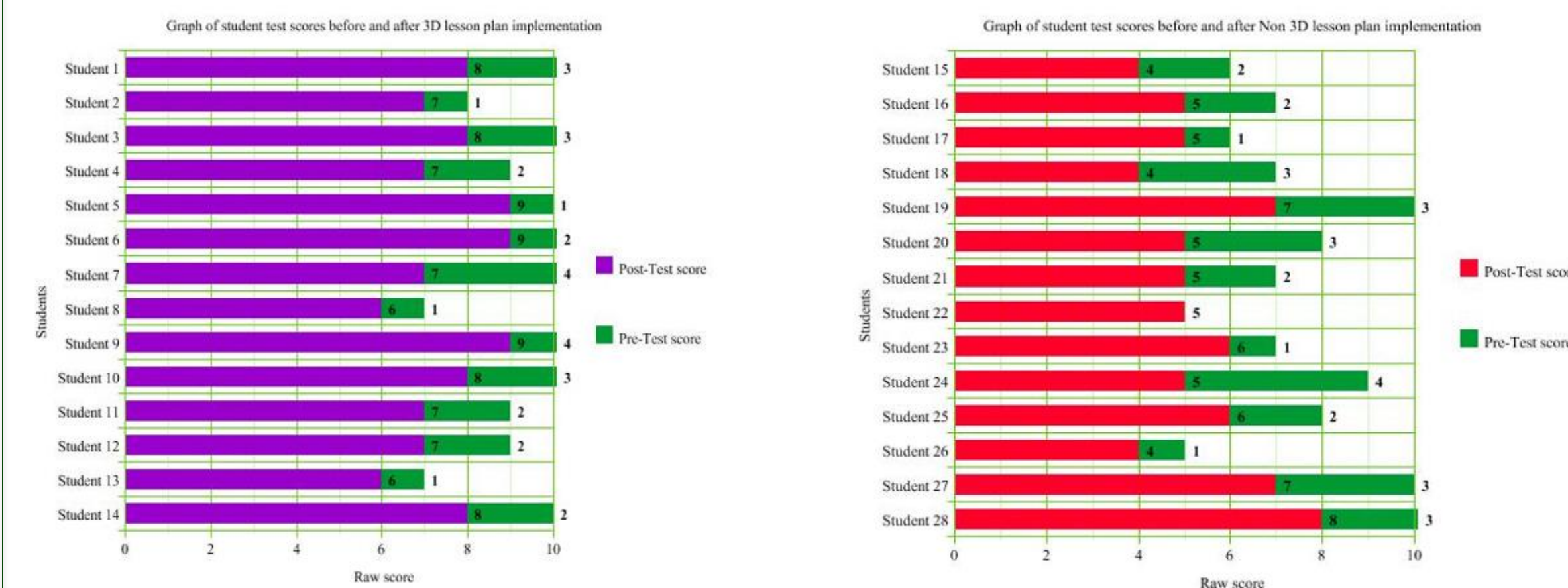


Figure 1: Graphs preliminary data

- Biomedical Engineering students used 3D printing as a prototyping tool for their class project (Figure 2). An example of their project is shown in Figure 3.

Teacher training: Following grant approval, the selected 5 Title I schools will be given trainings on the 3D printing software and classroom implementation of the proposed lesson plan. These trainings will only offered be to teachers scheduled to teach Biology Honors/Regular for that school year. All schools will use their respective 'Science Coach/Science Resource Teacher' as a point of contact for ongoing support from the investigation team. Teachers will learn how to navigate the "EASE 3D" web and phone application (Figure 3) as well be shown how to install/setup their 3D printers in their classrooms. Teachers will be paid \$25.00 per hour for the 4 hour training.

Implementation: At all 5 Title I school sites, students will take the online, multiple choice pre-assessment to measure their level of understanding prior to the proposed lesson plan..

Data analysis: Data collected from pre-tests, post-tests and Biology EOC scores will be analyzed and compared to other Title I schools in Hillsborough County.



Figure 2. Students from the class on Modern Biomedical Technologies present their final projects. Some of them hold their 3D printed devices in hands

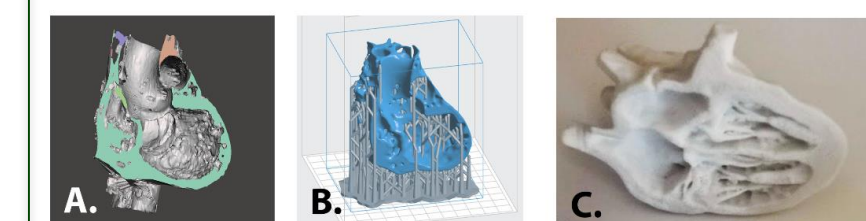


Figure 3. Model of a human heart. A. surface reconstruction, B. mesh in Form 1+ Software, C. 3D print.



Figure 4: EASE 3D Mobile Application

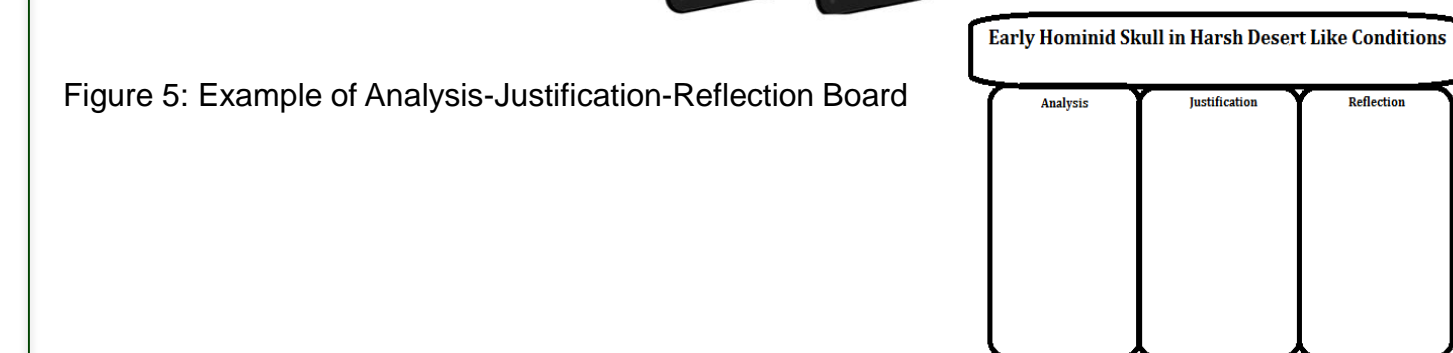


Figure 5: Example of Analysis-Justification-Reflection Board

**Conclusion**

Based on preliminary data, the use of 3D Printing within an inquiry based lesson does increase student learning and student test scores. The data shows promising results for implementation into a high school curriculum. Further results from data analysis will be done when test scores from high school students are provided.

**Referenced Resources**

- End-of-Course (EOC) Assessments. (n.d.). Retrieved July 25, 2016, from <http://www.fldoe.org/accountability/assessments/k-12-student-assessment/end-of-course-eoc-assessments/>
- Kaplan, H., & Pyayt, A. (2015). Tactile Visualization and 3D Printing for Education. Encyclopedia of Computer Graphics and Games, 1-8. doi:10.1007/978-3-319-08234-9\_57-1