An initial comparison of the learning propensities of 10 through 12 students for data analytics education

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***Abstract*—The main focus of this ongoing effort is to compare the learning propensities of 10 through 12 students for data analytics education. Towards this end, a Microsoft Excel based university-level environmental engineering module was taught in a high school classroom with students in grades 10 through 12. The module focused on understanding the current trends and challenges in environmental pollution management and policy. Students were required to procure, analyze, and visualize data in order to propose an environmental policy that was aimed at reducing pollution. Initial data collected from the assessment of the student work alludes to the fact that despite being taught the same material by the same professor and teaching assistant, the success of the students, as measured by their final grades, varies substantially with their academic year. The underclassmen in high school did not display the academic maturity and comprehension that was displayed by the high school seniors. On the other hand, seniors demonstrated a strong propensity to learn and perform well.**

I. Introduction

Data analytics is a vital skill for STEM students. The main focus of this ongoing study is to codify the learning outcomes of 10^{th} through 12^{th} grade students for data analytics education. This effort will introduce in high schools, several 5-week data analytics modules taught at Drexel University's (DU) College of Engineering (CoE). In general, these modules cover topics that provide students an introduction to the technical challenges in several branches of engineering.

Specifically, we present initial results of a data analytics module that covers concepts from environmental engineering. Environmental engineering has been shown to help raise students' knowledge and change their attitudes in perspective of environmental issues. In [1], the authors present efforts wherein curriculum was developed for high school and university engineering students dealing with environmental issues involving fuel and vehicle technologies.

Furthermore, this work is support by the National Science Foundations's GK-12 program [2]. The GK-12 program features innovative collaboration between graduate students, university professors and high-school teachers. This practice has yielded positive results in the past as evidenced by the host of success stories mentioned in [2]. Additional evidence of a successful collaboration between university professors and high school teachers is found in [3]. In [3], the authors present efforts that were based on collaboration with a university professor to bring the idea of "wonder" into a 9th grade science classroom. Two classes were taught, but only one was taught with a sense of trying to evoke "wonder". The general results of the project were both qualitative and quantitative through journals and tests showing that through the phenomena of "wonder" there was evidence to show that it provides better retention and understanding of the material, thus resulting in a a more effective learning process.

Ultimately, the content and empirical results generated from this effort will be shared on a web portal to help inform 1) the engineering data analytics education community of the benefits and limitations of introducing data analytics concepts in high schools, and 2) the ongoing national dialogue on big data education, thereby helping all stakeholders better align their STEM educational efforts.

II. Method

A sophomore level engineering module was conducted in a high school classroom with students in grades 10 through 12. The group of students were chosen as a class that was involved in the National Science Foundation GK-12 program. This class was more specifically chosen because it was an engineering focused class with a diverse group of grade-level students. To the best of our knowledge no student had previous Excel experience and the assignments were part of the students' grade for the semester. The module was taught twice a week for a five-week period. This module focused on data analytics exercises as applied to environmental engineering.

The instructional and learning strategies utilized in this effort were inspired by the observations and recommendations derived from the National Academy Press Report on How People Learn (Bransford, Brown, and Cocking, Eds) [4]. The lectures were designed to introduce environmental engineering concepts. During lectures, the instructor introduced data analytic topics in a contextual manner using Powerpoint slides, demonstrated data procurement, analysis, and visualizations using Excel, and provided general insights about the topic being covered. This instructional strategy is in line with the recommendations of [4], wherein the instructor presents "some subject matter in depth, providing many examples in which the concept is at work."

During the lecture, the instructor presented several fundamental questions pertaining to the technical challenges of environmental engineering and invited the students to discuss possible answers. The students take over the discussion while being gently guided by the instructor to arrive at an answer. By doing so, the instructor used the findings of [4] wherein the authors note, "students come to the classroom with preconceptions about how the world works and it is necessary to engage this initial understanding". This instructional strategy allowed the instructor to draw out and work with pre-existing understandings that students bring with them [4].

The labs sessions were designed to enhance students understanding of the topics covered in the lectures. Students worked in groups of 2 on biweekly lab assignments that featured open-ended questions about the following topics:

1) Global Emissions of Carbon Dioxide
2) Historical New Jersey temperatures
3) Particulate matter data from an environmental monitoring system installed in Philadelphia
4) Emissions due to the transportation sector in the US
5) Emissions due to the energy sector in the US

The open-ended questions were designed such that when answered via appropriate data analytics, the answers provided the building blocks of the environmental policy mentioned earlier.

Websites that host datasets required to perform this analysis were provided to the students. However, students were responsible for driving their own learning with minimal or no input from the instructor. They were encouraged to search for data sources, select the appropriate amounts/types of data, apply the relevant data analysis techniques, and generate visualizations and insights to answer the questions. They were also encouraged to refer to online journal articles, chapters of seminal textbooks in the field, the slides that was presented by the instructor, as well as any other reputed online resources that they could find. Students were also encouraged to talk to each other to share ideas, information and knowledge.

A. Lecture and Laboratory session organization

There was a 65-minute lecture and a 65-minute lab period per week. Students used Microsoft Excel and data analytics concepts such as descriptive and predictive statistics to analyze, visualize, and summarize the key trends for the aforementioned topics. The 5-week module consisted of two biweekly assignments and a final environmental policy. Each assignment consisted of an excel workbook as well as a one page memo of their findings.

B. Personnel

The college professor and the teaching assistant who taught the sophomore level engineering class also taught the high-school class. The professor, Pramod Abichandani, of the class, Evaluation and Presentation of Experimental Data (EPED) at Drexel University (DU), collaborated with Mr. Matthew VanKouwenberg, a high school engineering teacher at the Science Leadership Academy (SLA) for this effort. The material covered at the SLA was the same as that taught at the sophomore level in DU's EPED class. Also the GK-12 fellow, Jamie Kennedy, ran the labs at both DU and the SLA. Students were required to work in pairs during labs.

III. Preliminary Results

A total of 8 groups (16 students) at the SLA were part of the effort thus far. These were divided into the following two cohorts:

1) Cohort A: This group consisted of students from grades 10 and 11 at the SLA. A total of 5 such groups were part of this effort.
2) Cohort B: The remaining 3 groups consisted of grade 12 students at the SLA.

The assessment tools consisted of a combination of analytic and summative rubrics. All assessment was done by the GK-12 fellow. The difference between the final scores of Cohort A and Cohort B was substantial. The Cohort B was at 71.6 percent average grade while the Cohort A was at 45.3 percent average grade. There was improvement upon the Cohort B group with the averages of the assignments increasing from 27.7 to 54.0 percent throughout the 5-week period.

IV. Discussion and Future Work

The results allude to the fact that despite being taught the same material by the same professor and teaching assistant, the success of the students, as measured by their final grades, varies substantially with their academic year for the group of students involved in this effort. The Cohort A students did not display the academic maturity and comprehension that was displayed by the Cohort B and sophomore college students. On the other hand, seniors demonstrated a strong propensity to learn and perform well.

One possible reason for such a substantial difference can be the difference in the emotional intelligence of students. In a related study [5], the authors examine the relationship between emotional intelligence and academic achievement in the transition from high school to university level. The results showed that academic success was strongly related to several dimensions of emotional intelligence. Furthermore, in [6], the authors examines the relationship between emotional intelligence and academic retention in the transition from high school to university level. The experiment was done over the course of two years tracking students that remained enrolled with university studies over their first couple years and students that withdrew. Results showed that students that remained enrolled with their studies had a broad range of emotional and social competencies.

In summary, the initial comparison alludes to the fact that despite being introduced to the same environmental data analysis concepts and material, the seniors (12th grade students) performed relatively well in comparison to the underclassmen (10th and 11th grade students) as witnessed by their final grades. At this stage of the effort, several reasons for this difference in performance are hypothesized. These include difference in emotional intelligence (as discussed earlier) and motivation for the class. Furthermore, the difference may be a function of the technical focus (environmental engineering and/or data analytics) of the effort. Future work will focus on understanding the possible causes of differences in student propensities. As more assessment data is collected during these modules, we anticipate gaining a better understanding of the learning propensities of 10 through 12 students.

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