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Developing an Undergraduate Data Analytics Program for Non-Traditional Students

Lionel Mew
lmew@richmond.edu
University of Richmond
Richmond, VA.

Abstract

This paper discusses a new educational approach to develop competencies for the future STEM workforce, and to build knowledge on success factors for educating a non-traditional target population in data competencies. It is widely accepted that a data capable workforce is critical to science and industry. The literature suggests that the need for data science and data analytics competencies in industry and academia is accelerating at a rapid pace. At the same time, census and demographic data predict that the pool of traditional college age students will continue to decrease. To meet the increasing demand for a data capable workforce, it is essential to leverage the non-traditional student pool, reskilling and upskilling the current workforce, simply because the traditional student output is nowhere near sufficient to meet the need. The current work is to develop a new program designed to provide adult learners with bachelor's degrees and post baccalaureate certificates in Data Analytics. This results in upskilling or reskilling the existing workforce to add value to industry and academia. The program is differentiated from traditional programs by catering to non-traditional students through specific pedagogies such as incorporating required mathematics competencies into Data Analytics courses, using specific pedagogies proven to work with the non-traditional population, as well as removing constraints by offering evening courses, easing registration obstacles, etc. The paper suggests a proposed curriculum, as well as discussing the rationale behind each differentiated option.

Keywords: Data Analytics, Data Science, Workforce, Education, Non-Traditional, Student

1. Introduction

The Need

Data Analytics is emerging as a significant workforce need in the 21st century. One of the NSF's 10 Big Ideas is harnessing the Data Revolution (2018). This idea includes developing a 21st century data capable workforce (NSF, 2018; HDR@NSF, 2018). The literature suggests that the need for Data Science and Analytics (DSA) competencies in industry and academia is accelerating at a rapid pace. Many academic institutions have or are developing programs to meet this need. At the same time, however, census and demographic data predict that the pool of traditional college age students will continue to decrease. To meet the increasing demand for a data capable workforce, it is essential to leverage the non-traditional student pool, reskilling and upskilling the current workforce. The decreasing pool of traditional students is simply insufficient to meet current and future workforce needs in both data science and data analytics.

There are some troubling signs regarding the pool of traditional undergraduate students. The number of college age students grew from 1870, peaking in 2012 (Sklar, 2018). The number of 19-20 year olds in the US has plateaued, and the number of those under the age of 18 is diminishing. This has also been seen locally. For example, enrollments in the state community college system have decreased by some 25% from 2012 to the present. There are some enterprising efforts to create new pools of non-traditional students. Community colleges are starting pathways programs for high school students to gain workforce certificates, and 4-year colleges are recruiting the increasing number of high school students graduating with associate's degrees. Still, the fact remains that with a decreasing pool of traditional students and an increasing need for DSA in the workforce, traditional DSA students are insufficient to meet the need.

There is no question that there is an immediate requirement for data competent workers both nationally, regionally and locally. Nationally, Columbus (2018) notes that Glassdoor has listed Data Scientist as the #1 best job in America for the past three years. The Glassdoor report (2018) also lists Data Analyst in the top 50. In a Burning Glass Report, Markow et al. (2017) predict the number of data and analytics openings to increase by 364K from 2016 to 2018. Regionally, the Greater Washington Partnership coalition of industry and academia has developed a series of workforce digital credentials, including data analytics, to facilitate increasing the amount of STEM workers in the region to meet industry needs. Finally, locally, a June, 2018 report by the UPCEA Center for Research and Strategy identified data analytics as the most highly recommended new program for development by SPCS, based on a variety of environmental and demographic factors. The solution is to develop data competencies in non-traditional students to build them into the technical workforce of the future.

There are many students within the non-traditional demographic who would be obvious candidates for a DSA career. An example is the quantitatively competent student who attended college for a year, and who then dropped out since they were not ready for college, and lacked the maturity to succeed right out of high school. Now, 5 to 10 years later, they are ready to pick up where they left off. Another example is the person who, whether they completed a degree in a different field, or did not complete a degree, needs to upskill or be reskilled because they desire a career change or have hit a glass ceiling. There are also those who could not afford, or were not mature enough to complete a bachelor's degree. Some had to work for a living, and most will work fulltime as they complete their bachelor's degrees.

What is a Non-Traditional Student?

There is no universal definition of a non-traditional student. However, demographic information gives perspective to the typical School of Professional and Continuing Studies (SPCS) student. Entry data indicates that the average student age is 37. Although the majority of students have traditionally been men, the number of women in the program is slowly increasing, with women accounting for 46% of enrollments in 2015, and over ~50% of students in 2017 and 2018. Experience levels and goals of women are similar to those of the male students.

Eighty-one percent of students are part-time. For technology students, both part-time and fulltime students are working on either Bachelor of Science in Professional Studies degrees with a major in Information Technology Management or Information Security, or a post-bachelor Certificate in Applied Studies in Information Systems or Information Security. Student experience varies, with some having associate's degrees or at least some community college work, and have immediately transferred to SPCS with a desire to complete their bachelor's degree. Others have been in the workforce for some time, and need a degree for promotion. Still others are trying to break into the information systems field, often with significant life experience and success in other fields.

The result is that there is wide variance in student understanding, experience and ability. All of the major core courses are classroom courses, although some are offered in hybrid format. There are currently no completely online information systems courses, although some non-major courses may be taken online. Most of the students live in the local metropolitan area, and most stay in the area after they graduate. Courses are generally capped at 15 students, allowing significant individual attention and interaction with instructors.

This demographically diverse student population presents numerous opportunities as well as challenges. Many of these are well known and well documented elsewhere, such as the benefits of experience and maturity, and the challenges of family and work obligations. Whereas the traditional students continue to mature and learn to think critically during their degree programs, it is expected that the continuing students in this program focus more on professional competencies, with the focus for instructors to help students grow professionally.

2. LITERATURE REVIEW

There is no question that there is a need to reskill and upskill the current workforce to meet the needs of industry and academia for a data capable workforce based on National Science Foundation forecasts and priorities (NSF, 2018;

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HDR@NSF, 2018). The question is how to leverage the current workforce to that end.

Undergraduate DSA Programs for Traditional Students

While there are an increasing number of schools offering bachelor's level DSA programs, there are few oriented towards non-traditional students. According to Dataversity (2018), based on a forecast need for DSA professionals, many programs were developed, most of them leading to a master's degree. They note that while most lead to graduate degrees or certifications, there are several that result in bachelor's degrees, including Denison, Auburn, Arizona State, University of California – Irving and Smith College. There are an increasing number, including many not mentioned by Dataversity, including Trinity, Washington & Jefferson, Luther, Valparaiso, Iowa, Arkansas Tech, Northern Kentucky, St. Mary's, Brigham Young, Michigan and the University of Evansville. What all of the aforementioned programs have in common, however, is that they are oriented towards traditional students.

Non-Traditional Students Retention Factors

The factors affecting student dropout decisions are different for non-traditional students than for traditional students. In developing an attrition model for students, Spady (1970) finds academic performance to be the dominant factor in student dropout decisions, with social integration also a major factor. Tinto (1975) notes that many previous works did not differentiate academic failure from voluntary withdrawal, but that predictors of both are related to social integration, or lack thereof. Pascarella (1980) stresses the importance of informal faculty contact with students, with the implication that such contact positively affects social integration. Bean (1985) agrees with the previous studies with regards to the dominance of socialization, ad further suggests that peer interaction has a greater effect than faculty-student interaction. In a 1985 study, Bean and Metzner find that while previous studies on student attrition consistently find that social integration is a dominant factor in dropout decisions, it is considerably less important among non-traditional students. This is attributed to social and environmental variables outside the academic environment having a more significant role for non-traditional students.

Strategies and Pedagogies

Non-traditional students require different teaching and learning strategies. Knowles (1984) notes that adult learners are more self-directed and task oriented than traditional students. Because of these traits, Kenner and Weinerman (2011) suggest that instructors present material in ways that allow non-traditional students to see the purpose of the exercise. Failing that, instructors may face resistance to the learning strategy. Kenner and Weinerman further suggest that the material must be presented in a way that competes with previously learned learning strategies, so students understand the value of the new strategy. Further, they suggest that repetition be used, so that students can practice and discern the usefulness of the new strategies (2011).

Creative Programs

There are some programs that use interesting new approaches which may be applied to new programs. Denison approaches data analysis from a liberal arts standpoint, with a focus on critical thinking and problem solving. Participants are required to take interdisciplinary courses in a field of interest, which helps them assimilate applied problem solving. Valparaiso University has adopted a business analytics program that focuses less on technical aspects of data, and more on problem solving, visualization and communication. Ottawa University offers a fully online data science program designed for adult learners. Tenets of these programs may be added to the project program development.

3. DISCUSSION

This project develops a data analytics undergraduate and certificate program to upskill or reskill non-traditional students in data competencies, evaluate and report on the process, and deliver a model curriculum for others interested in implementing a program for this population.

The goal of this project is to facilitate and improve success of non-traditional students seeking to develop data competencies. This is accomplished by developing and researching a program dedicated to the non-traditional student population, report on the process, and deliver a successful model

SPCS is Mostly a Degree Completion Program

Although it is possible to complete a bachelor's degree solely at SPCS, most students bring from 45 – 60 hours from other institutions. Many come from the two local community colleges. Others bring in transfer credits from previous work. The bottom line is that students may transfer up to 60 credits into their programs. The challenge is to develop a program that develops student data

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competencies within the last 60 credit hours of their undergraduate tenure.

Additional Non-Traditional Student Issues

As most of the students are working, many fulltime, class meetings are constrained by their availability. Courses are anticipated to meet once a week, on Monday through Thursday nights, and on Saturdays. This schedule in itself requires adjustment and consideration to pedagogical delivery. If they have children involved in sports, their Saturdays may be compromised. The limited number of periods when courses may be offered affects scheduling. Prerequisites for courses must be minimized to ensure that students are able to have course options to complete their programs. Consideration must be given to students taking their required math courses, and math competencies are required for many of the DSA courses. Required math courses are Finite Math and Applied Statistics.

Necessary Math

Many community college graduates with associate's degrees have completed Introduction to Mathematics, which introduces number systems, logic, basic algebra, and descriptive statistics. This course is not accepted for transfer to any 4-year institution in the state. Others take the minimum transfer math course, Quantitative Reasoning, which introduces proportional reasoning, modeling, financial literacy and validity studies (logic and set theory) in a very much applied fashion. Finally, there are those who transfer in with Pre-Calculus and/or Calculus. While it is presumed that the latter would be the best candidates for a DSA program, the reality is that there is wide variance in the students typically transferring or entering SPCS programs. The question is what math is required for a DSA program for non-traditional students? Data Science Weekly (2013) suggests several competencies for the DS resume, including linear algebra, regression, probability theory, numerical analysis and core machine learning methods.

It is suggested that new approaches in curriculum and pedagogy are required to service the non-traditional demographic and ensure the success of these students. This is a new audience – students who may not have received a recent, college preparatory and heavily quantitative high school education, but who have the maturity and capability of working with data. Rather than forcing these students to undergo traditional quantitative courses to fill holes in their education, it involves integrating quantitative competencies into Data Analytics courses. It involves modifying pedagogies to place less stress on developing models, and more on using emerging and increasingly complex tools and cloud competencies to analyze, interpret and leverage the results. Critical thinking, problem solving and articulation of results are stressed. The challenge is to address the unique barriers to success for these students, ensuring their success in a data driven world. The specific math components covered in each course is driven by course content, and is anticipated to be developed as the courses are designed.

Sharp Sight Labs (2016) suggests that the amount of math necessary for entry level positions in industry (machine learning in this case) is not as much as one might expect. They posit that if one is educated in academia, there is a significant amount of math required, since academics research and develop the tools used by industry. As workers in industry, Sharp Sight Labs suggests that entry-level personnel spend more time using the tools to add value to the enterprise. This raises the question of the balance between modeling and algorithms, and using automated tools.

Labs and Tools

Many experienced practitioners cast aspersions on a perceived increasing proclivity of analysts to use automated tools and pre-configured dashboards. In information systems, the same has been said about automated database development tools and commercial-off-the-shelf-software for decades. However, as technology emerges, there is value in automating some repetitive functions, as well as some complex ones made easier using tools. That is not to say that students do not have to understand the algorithms and concepts used to develop models.

Wilder and Qzgur (2015) propose a business analytics program designed for non-technical business students. Manyika (2011) suggests that the US alone may face a shortage of between 140K to 190K positions requiring deep analytical skills, and 1.5 million managers and analysts who can analyze big data to make decisions. Although the article is somewhat dated, what is significant is the distinction between hard data scientists, and managers and analysts who can use the tools to add value to the enterprise by making decisions. Similarly, Markow et al. (2017) state that positions for data scientists and other advanced analytics competencies will reach 61,799. However, that number is only 2% of positions requiring data and analytics competencies. Wilder and Ozgur describe a program where data competent managers use problem solving, visualization and communications skills to add value.

In this project, it is not proposed that a technically light program be developed to focus on business skills. It is instead proposed that the program focus on ensuring students have sufficient math integrated into their courses for them to internalize concepts. Then, instead of modeling analyses, they use advanced tools to then understand patterns and solve problems, visualize and communicate their findings. The program development portion of this project includes building cloud labs to include emerging technologies and tools to keep students on the cutting edge of analysis techniques.

4. Program Development

To summarize the discussion, the work of the new DSA program development must consider the following:

- It is anticipated that the need for DSA workers will increase, requiring additional entrants
- The traditional undergraduate pool is decreasing, requiring additional new populations
- Developing programs for non-traditional students will help meet demand
- Most undergraduate DSA programs are designed for traditional students, requiring tailored programs for non-traditional students
- Retention factors are different for non-traditional students, requiring different strategies
- Adult learners require different pedagogical approaches, requiring tailored programs
- There are some creative programs which should be examined and best practices noted
- SPCS is a degree completion program, with ~60 credit hours to cover all topics, making efficiency a major goal
- There is a lot of variance in student math preparation, which must be addressed
- Required math competencies are integrated into data courses, to be further addressed as courses are developed
- Entry level analytics positions focus on tools rather than modeling, so the program focuses on tools and visualization
- Courses develop use of tools, problem solving, visualization, communications
- Data science reflects only a small percentage of data and analytics positions
- Emerging technologies enable advanced analytics tools, so additional focus on tools is warranted
- Cloud labs are developed to facilitate the latest tools, easing lab requirements and improving capabilities
- A program for non-traditional students is developed and implemented and a model curriculum is developed
- A research project will report on program success, process and lessons learned

The goal of program development is to develop, implement and staff a program designed for non-traditional undergraduate and post-bachelor's career transitioning students seeking to develop data competencies. This involves developing an innovative DSA program to meet the unique needs of non-traditional students.

This work consists of developing a program or both bachelor's programs and Certificates of Applied Studies in Data Analytics. This involves developing a curriculum optimized to facilitate the success of the target population, meeting the requirements of accreditation and program operationalization in conjunction with the university Office of Institutional Effectiveness. Other analytics curricula are examined, and a program is developed with an emphasis on ensuring basic concepts are understood with required math integrated into courses, then focusing on framing problems, selecting analysis methods and tools, conducting and interpreting the analysis, and presenting the analysis so decisions can be made.

Once the development is complete, the new program must be approved internally by school faculty, Academic Council, Board of Trustees, etc. It is then sent for approval by the Southern Association of Colleges and Schools Commission on Colleges (SACSOC) is the regional body for the accreditation of degree-granting higher education institutions in the Southern states. Once SACSOC and tuition assistance approval are granted, the program can begin accepting students. It is hoped that this will occur in the fall of 2020.

Quantitative and other requisite competencies will be integrated into such new courses as Data Management, Prescriptive Analytics, Descriptive Analytics, Predictive Analytics and Data Visualization. As most of the students are working, many fulltime, class meetings are constrained by their availability. Courses are anticipated to meet once a week, on Monday through Thursday nights, and on Saturdays. This schedule in itself requires specific pedagogies and methods to facilitate learning specifically targeted to adult learners.

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By offering students a new major, Data Analytics, in the Bachelor of Science in Professional Studies (BSPS) program, and a post-baccalaureate Certificate of Applied Studies (CAS), SPCS believes it can further expand its program offerings to prepare students for data analytics positions in private industry and government organizations. Admission requirements for this new major will be the same as SPCS' current BSPS. The BSPS in Data Analytics focuses on what is needed for a specialized major in Data Analytics in addition to the existing structure of other majors. The Data Analytics major shares courses with the BSPS in IT Management and other BSPS majors.

In addition to the BSPS bachelor's degree requirements, the major in Data Analytics requires successful completion of 30 semester hours of undergraduate coursework in the major: 21 semester hours from the six required courses and 9 semester hours from the Professional Core courses. These Professional Core Courses (9 credits) for the BSPS in Data Analytics are the same as the BSPS in IT Management – Applied Ethics (3 credits); Leadership in the Global Environment (3); and Applied Statistics (3).

SPCS has established an initial enrollment target for the BSPS in Data Analytics major of 15-25 new students per year. Estimated potential student interest at the post-baccalaureate certificate level is an additional 10-20 new students per year beyond the number of students in the bachelor's program. Again, the program is expected to start in the fall of 2020.

The CAS in Information Security program requires a minimum of a bachelor's degree with a 2.0 cumulative grade point average (GPA) or higher. This is the same admission requirement as the current CAS program in Information Systems. Admission to the bachelor's degree also requires a 2.0 cumulative GPA on all college work. This is less selective than most DSA programs, again making the program structure important to student success.

Curriculum

The Data Analytics degree structure is based on the current BSPS degrees in Information Technology Management and IT Security. Requirements for the BSPS Major (21 credits*) and CAS in Data Analytics (18 credits) include the following:

- DSDA 3XXU Descriptive Analytics
- DSDA 3XXU Predictive Analytics
- DSDA 3XXU Prescriptive Analytics
- DSDA 3XXU Data Visualization
- DSDA 3XXU Data Analytics Elective
- DSDA 4XXU Data Analytics Capstone

All of the courses above are developed specifically for the program to include pedagogies specific to non-traditional students. These initial courses are loosely based on the business analytics curriculum described by Wilder and Ozgur (2015). Descriptions and justifications are as follows:

DSDA 3XXU Descriptive Analytics – the goal of this course is to introduce students to effectively describing events that have already transpired. Applied Statistics, is a prerequisite for this course. Applied Statistics gives the student a foundation in descriptive statistics, and this course strengthens that foundation and focuses on use of software, interpretation, problem solving and communication of results. This course takes Applied Statistics to the next step, and ensures that students have a strong foundation in basic statistical technique.

DSDA3XXU Predictive Analytics – the goal of this course is to which introduce students to determining future outcomes and trends from existing data to help predict new relationships. Students evaluate potential outcomes based on historical data predictors. Students use their problem solving skills, framing the problem, data sources, models and analysis methods. They then learn to apply predictive analysis methods, use analysis tools popular in industry. The course prepares students to complete a cycle of framing a problem, identifying data sources analyzing, interpreting and articulating the results. Descriptive Analytics is a prerequisite for this course. Being able to derive future outcomes from existing data is essential to a career as a data analyst.

DSDA 3XXU Prescriptive Analytics – this course presents a comprehensive overview of the theory and practice of how to apply Prescriptive Analytics and optimization. The workflow for Prescriptive Analytics is discussed, from understanding the problem through selecting the approach and data, constructing simple models, and completing the analysis and interpreting and communicating the results. Descriptive Analytics is a prerequisite for this course.

DSDA 3XXU Data Visualization – this course teaches students various diverse techniques for presenting data to a targeted audience. Various tools and emerging technologies are used to visually present data to the best effect. Emphasis is placed on clear, simple communication. The

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goal is to give students the competence to explain complex concepts in simple terms.

DSDA 3XXU Data Analytics Capstone – the goal of this course is to ensure that students are able to manage and complete a real world analytics project. Project management and consulting basics are covered, as are client interaction and use of real world data. Students must frame the problem and choose and execute an appropriate analytics methodology. This should be the last course in a student's program. This is seen as an important part of the student's program. SPCS prides itself on the relevance of their students in the workforce. Having an applied practicum strongly supports this goal.

DSDA 3XXU Big Data Fundamentals The student learns that big data is not simply business as usual and the decision to adopt big data must take into account many enterprise and technology considerations. During the course, students examine current approaches to enterprise data warehousing and business intelligence. In addition, they explore key concepts related to the storage of big data datasets and how big data datasets are processed by leveraging distributed and parallel processing capabilities that have converged in the big data space. They also study the implementation of different flavors of NOSQL technology. Using the understanding of the big data paradigm students learn a range of big data analysis techniques. This course would ideally be a required major course, but there is not room under the existing curriculum structure, so it is offered as an elective in the proposed program.

Electives in data analytics will be offered throughout the program. A course in data mining will be offered, where students are taught to recognize opportunities for data mining approaches and exploit the results. A machine learning course will provide an introduction to basic machine learning methods, covering theoretical foundations and essential algorithms for supervised and unsupervised learning.

Field specific courses may be offered in collaboration with other programs, resulting in courses such as human relations analytics and analytics for education. A course in data management will help students learn to manage data as an enterprise asset.

The program is innovative in adopting practices, and culture designed to help non-traditional students succeed. These include:

- Specific learning strategies and pedagogical approaches
- Math competencies integrated
- Class schedule designed for working adults
- Assignments oriented towards non-traditional students
- Consideration for external social and environmental factors
- Focus on tools, interpretation and communication
- Use of cloud labs for improved access
- Use of emerging technologies, etc.

Program enhancement
At the end of each semester, results from each of the feedback collected are examined with a goal of refining each course to improve it the next time it is offered. Three feedback mechanisms are used:

Proposed Program Learning Outcomes

Outcome 1 – Students will be able to choose appropriate models of analysis, assess the quality of input, derive insight from results, and investigate potential issues.

Outcome 2 – Students will understand effective management of data as a corporate asset that underlies enterprise systems, including techniques and controls for information security.

Outcome 3 – Students will be able to apply principles of data analytics, including areas such as descriptive analytics, predictive analytics, prescriptive analytics, data visualization to complete analysis.

Outcome 4 – Students will be able to interpret, visualize and communicate results with clients.

Labs
The requirements for labs for this program differ from that of traditional programs due to the presentation to non-traditional students as well as because of emerging technologies and paradigms. As previously mentioned, one of the key tenets of this program is for students to learn to use new tools that simplify data modeling and analysis. Non-traditional students, with their once-per-week class schedule combined with often busy work schedules, need non-traditional lab access. These tools are anticipated to be further defined as courses are developed.

At the same time, paradigms are changing around institutional support of information technology courses. The infrastructure costs of locally hosted applications are increasing to the point where a paradigm shift to cloud based applications is inevitable (Mew, 2015).

An example of this are two relevant courses currently offered by SPCS. The first is relational database and business intelligence course using an Oracle database. The database uses a university license on a locally hosted server. The university has traditionally supported this course with the enterprise license, but there is no guarantee what would happen if the server fails or the enterprise license is allowed to expire. The second example is a new course on big data analysis. The course requires students to use the industry standard MongoDB cross-platform document-oriented database program. With the university information services unable to host the program locally, MongoDB was hosted on an Amazon Elastic Compute Cloud (Amazon EC2) instance on Amazon Web Services. The advantages of using cloud-based applications are numerous.

Contribution and Future Research

This project adds to the body of knowledge by extending development of DSA programs to the non-traditional student population. It develops a program, optimizes the program through four iterations of a spiral development methodology, and assesses the outcome. It develops a model curriculum, and publishes the curriculum and outcome of the research project.

Follow-on research would provide insight into how this project will develop metrics to determine whether the innovations instituted to cater to a non-traditional population have contributed to the academic success of these students. It is suggested that these Non-Traditional Student Program Innovations (NTSI) have a positive impact on student success. The measure of student success is in the context of how well the program has prepared the student to meet personal, academic and professional goals espoused by the program.

5. SUMMARY

This program is anticipated to be an inspiration for others desiring to implement a Data Analytics program for adult learners. A program is developed and iteratively improved through feedback over the course of 5 years. It is a cross-disciplinary approach which is highly adaptable to other scenarios, and it results in a refined model curriculum and a lessons learned repository. Finally, research about the project adds to the body of knowledge on developing data analytics programs for non-traditional students.

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