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Aligning higher education with demands for data science workforce

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The lack of employment opportunities remains one of the drivers of poverty in the Philippines. With the advent of the Fourth Industrial Revolution (FIRe), however, comes the increasing demand for data science and analytics (DSA) workforce, which can help mitigate this issue on employment. Sadly, DSA skills remain underdeveloped among the Philippine workforce. Behind this is the school-industry gap, wherein educational institutions fail to hone skills that meet industry demands (Tan and Tang 2016).

This *Policy Note* answers the question: "Are Philippine undergraduate programs able to supply the demand for DSA professionals?" It provides evidence on the current DSA skill gaps in the Philippines in light of the country's preparation for FIRe. It also identifies specific DSA competencies and recommends actions to address the challenges in preparing the future DSA workforce.

Data science and analytics

The rapid advancement of technology has allowed big data to become an invaluable economic resource for many institutions. This economic potential of big data has caused DSA to be a popular field across sectors. However, despite this popularity, there continues to be a lack of consensus as to the definition of DSA. Understandably, DSA involves a wide range of skills that could not easily be captured by a single definition (Demchenko 2017).

This study adopted the operational definition of "analytics" by the Analytics Association of the Philippines (AAP). According to AAP (2018), analytics is the "process of progressing data along the value chain as it transforms data to information to insight to imperatives with the purpose of delivering the right decision support to the right people and digital processes at the right time for the good of society." With such definition, the specific attributes of DSA as identified by varying references are captured (APEC Human Resource Development Working Group 2017; Demchenko 2017; PwC and BHEF 2017; Tan and Tan n.d.).

This study likewise employed AAP's Professional Maturity Model to determine whether the Philippine undergraduate programs can supply the current and emerging demands for DSA talents (Table 1).

This model identifies four DSA professional job roles, namely, data steward, data engineer, data scientist, and functional analyst defined as follows:

1. Data steward: Develops, enforces, and maintains a data governance process to ensure that data assets provide the organization with high-quality data.
2. Data engineer: Designs, constructs, tests, and maintains data infrastructures, including applications that extract, transform, and load data from transactional systems to centralized data repositories.

Table 1. Analytics Association of the Philippines' professional maturity model

DSA Competencies	DSA Professional Job Roles			
	Data Steward	Data Engineer	Data Scientist	Functional Analyst
Domain Knowledge	3	1	2	3
Data Governance	3	2	2	2
Operational Analytics	3	3	3	3
Data Visualization	2	1	2	3
Research Methods	1	1	3	1
Data Engineering	-	3	1	-
Statistical Techniques	-	1	3	-
Methods and Algorithms	-	1	3	-
Computing	1	2	3	1
21st Century Skills	3	3	3	3

DSA = data science and analytics
Note: Level 1 – beginner/basic proficiency; Level 2 – intermediate/average proficiency; Level 3 –expert/ advanced -level proficiency
Source: AAP (2018)

3. Data scientist: Leverages statistical techniques and creates analytical models to derive new insights from quantitative and qualitative data.
4. Functional analyst: Utilizes data and leverages on derived insights to help organizations make better decisions in a specific functional domain.

The professional job roles are characterized by a set of 10 applicable DSA competencies with the required proficiency level, namely, basic, average, and advanced (APEC Human Resource Development Working Group 2017). Below are the definitions of these 10 DSA competencies:

1. Operational analytics - use general and specialized business analytics techniques for the investigation of all relevant data to derive insight for decisionmaking.
2. Data visualization and presentation - create and communicate actionable insights from data using visualization and presentation tools and technologies.
3. Data management and governance – develop and implement data management strategies, incorporating privacy and data security, policies and regulations, and ethical considerations.
4. Domain knowledge and application - apply domain related knowledge and insights to effectively contextualize data, achieved by practical experience and exposure to emerging innovations.
5. Statistical techniques - apply statistical concepts and methodologies to data analysis.
6. Computing - apply information technology and computational thinking and utilize programming languages and software and hardware solutions for data analysis.
7. Methods and algorithms - implement and evaluate machine learning methods and algorithms on the data to derive insights for decisionmaking.
8. Research methods - utilize the scientific and engineering methods to discover and create new knowledge and insights.
9. Data science engineering principles - use software and system engineering principles and modern computer technologies to develop DSA applications.
10. 21st century skills - exhibit cross-cutting skills essential for analytics at all levels, including, but not limited to, collaboration, ethical mindset, empathy, social and societal awareness, dynamic (self) reskilling, and entrepreneurship.

DSA competencies in the current workforce

Out of 1,271 activities listed in the Philippine Standard Industry Code, 22 activities required any of the 10 DSA competencies. Majority of these DSA-related activities belong to the information and communications subsector (41%), followed by the manufacturing subsector (34%), and the professional, scientific, and technical activities subsector (24%). The study estimated that about 174,000 workers in 2016 performed these activities and consequently were assumed to possess any of the DSA competencies. This figure was only 0.4 percent[1] of the total labor force in the Philippines in the said year. Almost half of these DSA-competent workers (42%)[2] belonged to the information technology and business process management (IT-BPM) industry.

[1] Authors' computations given there were about 41 million workers in the country in 2016 (PSA 2016).
[2] This is also supported by the data gathered through online job scraping. Job postings online can be a reliable source of pinning down current demand for DSA workforce as affirmed in our interviews with some hiring managers of IT-BPM companies in the country.

Current demand for DSA job roles

DSA is at the very nascent stage in the Philippines. Its journey begins with convincing leadership that data is the new "oil" of the organization. This challenging task of getting the buy-in of top executives certainly falls on those who operate the business as they can articulate how data can deliver their operational targets.

The online scraping of job postings in early 2019 revealed the skills that employers sought from DSA professionals. Bulk (66%) of the demand for DSA professionals in early 2019 was for the functional analyst role (Figure 1).

Once the top management has decided to embrace DSA, the next important DSA job role is the data engineer, who ensures that data at their right form are easily available for analytics. Rightly, the second (20%) most sought role was the data engineer. This demand for the data engineer, however, may be conflated with the software engineer role leading to a lower in demand for the data engineer.

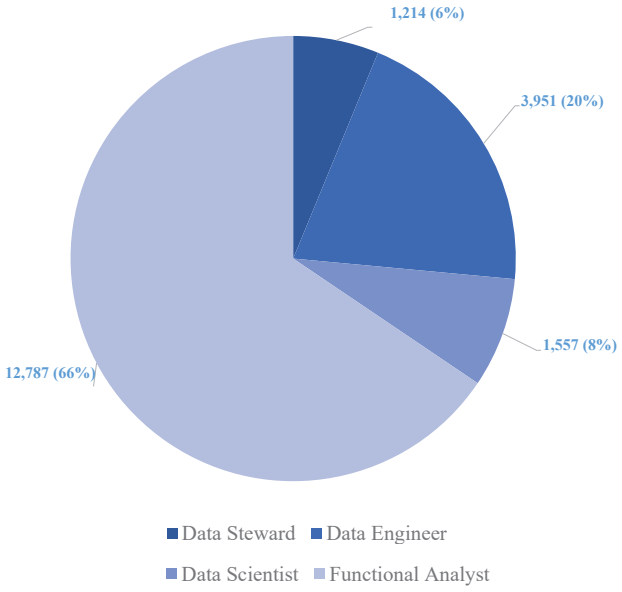
Only with clean data in data warehouses can algorithms be applied on data for insights. The low demand for data scientist (8%) showed that companies did not have their data ready for the DSA process.

The Facebook and Cambridge Analytica scandal in 2018 revealed the dark side of analytics. It showed how the data of millions of Facebook users were used without their consent for political advertisement in the 2016 election in the United States and Brexit campaign in the United Kingdom (MacASkill 2018). When data are misused, ethical issues on human rights arise and put society at risk. Since then, governments have tightened the implementation of data privacy laws. In the Philippines, the Data Privacy Act was passed in 2012 with the National Privacy Commission as the mandated implementing agency (NPC n.d.). Hence, the demand for data steward has been slightly evident (6%) in early 2019.

Work analysis on demanded DSA professionals

The AAP Model does not require data engineering, statistical techniques, and methods and algorithms competencies for the work of a data steward. Employers, however, considered these three as important, together with all the other competencies. The inclusion of data engineering could be attributed to the fact that the task of drafting and implementing data governance policies requires an understanding of data systems.

Figure 1. Demand for DSA professionals, Philippines: 2019



Source: Authors' online job scraping

The AAP Model and employers agree that all the competencies are needed for the position of a data engineer. Employers ranked data engineering, computing, and 21st century skills as the most important ones. Meanwhile, the AAP Model requires an advanced level of proficiency for data engineering and 21st century skills and only an intermediate level for computing.

Like the data engineer role, the AAP Model and employers agree that all the competencies are needed for data scientist. The three most needed competencies according to employers were data engineering, statistical techniques, and 21st century skills. The AAP Model requires advanced expertise in statistical techniques, research methods and 21st century skills, and only a basic proficiency in data engineering. The treatment of data engineering as a key competency among employers reflects the current work of data scientists, which includes data preparation, model building, and implementation of algorithms. Two other competencies that require an advanced level of proficiency

are operational analytics and methods and algorithms as per the AAP Model. Employers, however, did not perceive these competencies as crucial to the work of a data scientist.

The AAP Model excludes some competencies for the functional analyst role. These are data engineering, statistical techniques, and methods and algorithms. For employers, however, all the competencies are needed, specially 21st century skills, data engineering, and data governance. The necessity for data engineering may indicate that functional analysts are expected to perform a few tasks of the data engineer and the data scientist.

Current supply of DSA competencies

This study surveyed the undergraduate degrees of current DSA practitioners in the Philippines. The top 10 of these undergraduate degrees were considered as DSA-related programs, namely, computer science, business administration, statistics, mathematics, information technology, library and information science, economics, physics, industrial engineering, and civil engineering. Among these, the most popular DSA-related programs were computer science, business administration, and statistics.

The undergraduate programs mostly offered by higher education institutions (HEIs) in 2016 were business administration (57%), information technology (56%), and computer science (38%) (CHED 2019). Very few HEIs offer other DSA-related programs.

In 2019, the 10 DSA-related programs produced 176,597 professionals. Among these graduates, 62,583 (38%) were assessed to be "ready" to shift to DSA since they have been prepared to perform at least one DSA job role.

The industrial engineering program best prepares students for DSA jobs. New industrial engineers may immediately work as data stewards, data engineers, or functional analysts. Their research methods, methods and algorithms, and computing competencies need to be strengthened to also enable them or the work of a data scientist.

The next best DSA-related program for the data engineer and data scientist roles is computer science. Nonetheless, its graduates still need upskilling in the domain knowledge and operational analytics competencies to be ready to work as data stewards or functional analysts.

Data scientist employment may be offered to new mathematicians and physicists. They are not immediately ready to perform data stewards and functional analysts because they still need to learn more on data management and widen the application of their techniques outside of their respective fields.

The information technology program enables its graduates to be data engineers. Its graduates have been equipped with the foundational skills of data architectures, data infrastructures, and data security.

New economists may serve as functional analysts with their deep training in conducting research. To be prepared to work as data scientists, they just need a bit more skills upgrading, specially in computing.

While only 16 HEIs (0.82%) offer the statistics program, there are relatively a good number of DSA practitioners who have this degree. Curriculum statistics assessed by this study should provide students with fundamental knowledge and skills related to data science. Nonetheless, the evaluators were not able to ascertain the sample curriculum's ability to equip the students with the basic proficiency of all the competencies due to lack of details in the courses' descriptions.

Similarly, DSA practitioners with undergraduate degrees in business administration, library science, and civil engineering must acquire the basic proficiency of all the DSA competencies through other means.

In 2019, DSA-ready graduates were estimated to be 62,583. Since some programs enable their graduates to take on multiple DSA job roles, these "DSA ready" graduates can fill-in 81,078 DSA job roles. Of these available DSA job roles, 72 percent are data engineer roles, followed by data scientist roles (16%), functional analyst roles (7%), and data steward roles (5%). Furthermore, comparing the percentage distributions of demand and supply of DSA professionals (Table 2), the study found a misalignment between the type of DSA workers sought by employers and the type of DSA

Table 2. Demand and supply (in %) of DSA professionals, Philippines: 2019

	Data Steward	Data Engineer	Data Scientist	Functional Analyst
Demand	6	20	8	66
Supply	5	72	16	7

Source: Authors' computations

graduates produced by HEIs in 2019. Majority of employers were looking for functional analysts (66%) while HEIs were mostly producing data engineers (72%).

Conclusion

The findings indicated a scarcity of DSA competencies in the current workforce and a misalignment between the demand and supply of DSA professionals in the country. While employers were looking for graduates enabled to perform the work of a functional analyst, HEIs were producing graduates apt to be data engineers. Consistently, DSA-related degree programs equipped their graduates with the basic proficiency of the competencies that are required to perform the tasks of a data engineer or data scientist. Such misalignment can be attributed to the fact that DSA is still at its infancy in the Philippines. Hence, job roles are not particularized. Employers also run the risk of failing to hire the right worker for the right set of tasks. This was evident in the discrepancies between employers' expectations and AAP's definition of the DSA job roles. With this misalignment comes the impetus for the government to work on appropriate mechanisms. If not, youth unemployment may exacerbate.

It must be noted, once again, that the undergraduate programs evaluated in this study did not intend to produce DSA professionals. Consequently, evaluators assessed the curricula with the lenses of their respective disciplines. Moreover, it can be assumed that the graduates of these programs did not intend to be DSA professionals when they decided to take these programs.

Furthermore, while the sample curriculum contains the minimum requirements of the degree program and serves as a guide for HEIs in developing their actual curriculum, the paper evaluation of the sample curriculum did not consider other factors that affect the delivery of instruction such as teacher qualifications, teaching materials, facilities, and evaluation tools, among others.

Recommendations

Based on the foregoing, this study advances two main recommendations. First is the need to adopt AAP's framework to define DSA. Currently, AAP's professional maturity model is being enhanced and can be an appropriate starting point in aligning the demand and supply of DSA workers and competencies in the country. A common understanding of this emerging market for DSA workforce can benefit the different stakeholders.

- AAP must continuously update its professional maturity model to ensure its validity and relevance to the Philippines.
- Analytics companies can make use of the framework as basis for hiring and developing DSA talents.
- Relevant government agencies, such as the Department of Trade and Industry (DTI) and the Department of Information and Communications Technology (DICT) can collaborate with industry players more efficiently through policies and programs fitting to the industry needs.
- The Commission on Higher Education (CHED) can use the framework in creating new standards for the degree programs in DSA or in updating existing CHED memorandum orders (CMOs) of DSA-related degree programs to accommodate the DSA competencies as learning outcomes.
- HEIs can use the framework to design programs in DSA, improve their existing programs, and increase their capability in enabling their graduates to be industry-ready DSA workers.
- The government must increase the public's awareness of the DSA profession so students can choose a DSA career by taking related undergraduate programs.

Second is to promote government-industry-academe linkages. In this regard, stakeholders can consider the following recommendations:

- The academe, industry, and government through CHED can work together in establishing standards for degree programs or updating CMOs of DSA-related degree programs.
- The academe can involve the industry in improving curriculum, course design, and delivery of instructions or in co-developing teaching materials. Companies can share their cases and data.
- Industry players can encourage their own employees to impart a practical background of the DSA field to students.

- Companies can share in the cost of DSA education, such as data laboratories, hardware, and software licenses.
- Industry players can help intensify faculty development through faculty exchange programs and other industry research collaborations aimed to increase teachers' theoretical and practical background of the field.
- The government, through the following agencies, can work closely with industry and academe in formulating policies and programs that promote DSA:
    1. DTI can facilitate the evolution of analytics as an industry.
    2. DICT can enable the needed information and communication technology infrastructure for DSA.
    3. The Department of Labor and Employment can facilitate the healthy balance between the demand and supply of DSA workforce.
    4. The Department of Science and Technology can encourage the conduct of research projects in DSA.
    5. The Philippine Statistics Authority can include DSA in its databases and studies.
    6. CHED can promote DSA education among HEIs.

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