

Higher Education Institutions Data Viz 1.0: Visualization Tool for Decision-Making

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Abstract

As part of the Commission on Higher Education's (CHED) thrust for improving efficiency and effectiveness by simplifying the collection process for all the stakeholders, the CHED DataViz 1.0 tool will drastically improve the availability of data for making informed decisions and efficient generation of reports by presenting it in a visualized format. This research outlines opportunities associated with the implementation and governance of Big Data in higher education through development and implementation of CHED Higher Education Institution DataViz 1.0, a data analytics tool for decision-making.

Keywords: Big data; Data Visualization; Data-driven Decision Making.

1. Introduction

As per Joint Memorandum Circular No. 2012-01, Medium-Term Information and Communications Technology Harmonization Initiative (MITHI) is a process that harmonizes and ensures interoperability among ICT-related resources, programs, and projects across the government. It is the process for coordinating the planning, budgeting, implementing, and evaluation of ICT resources and projects in government. MITHI hopes to institute a mechanism to ensure a systematic process for the planning, budgeting, implementation, monitoring, and evaluation of a harmonized government-wide ICT blueprint. Thus, the pertinent Joint Memorandum Circular here attached was executed by the Convenor-Agencies in fulfillment of their respective and collective mandates. MITHI covers all ICT-related resources, programs, and projects of NGAs, GOCCs, and SUCs [1].

To fully realize the objective of Joint Memorandum Circular No. 2012-01, the Commission on Higher Education continue to streamline processes in data collection pursuant to CHED Memorandum Order No. 45, s. 2016, the Commission is mandated to collect, collate, store and disseminate data and information needed by the public and stakeholders to make informed choices and decisions.

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The Commission also needs higher education data/information as basis for formulating policies on instruction, research and extension as well as for monitoring the higher education sector's progressive relative to CHED strategic plan. All the Higher Education Institutions (HEIs) in the region are hereby requested to accomplish/update the forms in the CHED Electronic Collection and Knowledge (CHECK) System [2].

To strengthen the higher education institutions in the region, organizational and human development programs shall be conducted, and facilities and operating systems shall be upgraded and modernized. The complexity of these changes has far-reaching impacts that affect every aspect of provision. There are also growing regulatory demands for transparency and accountability, further as management strives to implement better evidence-based decision-making processes using Big Data and Data Analytics.

This research outlines opportunities associated with the implementation and governance of Big Data in higher education through development and implementation of CHED Higher Education Institution DataViz 1.0, a data analytics tool for decision-making.

2. Big Data Emergence in Higher Education

Big Data is a knowledge system that is already changing the objects of knowledge and social theory in many fields while also having the potential to transform management decision-making [3]. As learning technologies continue to penetrate all facets of higher education, Big Data can be utilized by policy-makers to adapt better in response to changes happening within and outside their environment.

Big Data brings new opportunities and challenges for higher education institutions and its framework efficiently utilize the vast array of data and ultimately shaping the future of higher education and technological developments. The utilization of big data served as catalyst for the move towards the growth of analytics in higher education.

2.1 Big Data

The Open Data Philippines (ODP), as a program, is a key commitment by its program managers to the Good Governance and Anti-Corruption (GGAC) Cluster, and consequently by the Cluster to the people. The program is likewise a commitment to the Open Government Partnership (OGP), a multilateral initiative that aims to secure concrete commitments from governments to promote transparency, empower citizens, fight corruption, and harness new technologies to strengthen governance. The program also seeks to drive government decision making based on available and sound data [4].

This ensures that data is broadly accessible to civil servants and government decision makers to create a data-driven culture within the government bureaucracy. The program recognizes that a citizenry empowered with open government data can help improve government's service delivery.

In a broad range of application areas, data is being collected at unprecedented scale. Decisions that previously were based on guesswork, or on painstakingly constructed models of reality, can now be made based on the data itself. The concept of Big Data gained momentum in the early 2000s when industry analyst Doug Laney articulated the now-mainstream definition of big data as the three Vs namely Volume, Velocity and Variety [5].

Volume refers to the organizations' collected data from a variety of sources, including business transactions, social media and information from sensor or machine-to-machine data. Velocity streams in at an unprecedented speed and must be dealt with in a timely manner. RFID tags, sensors and smart metering are driving the need to deal with torrents of data in near-real time. Variety of data comes in all types of formats – from structured, numeric data in traditional databases to unstructured text documents, email, video, audio, and financial transactions.

2.2 Data Visualization

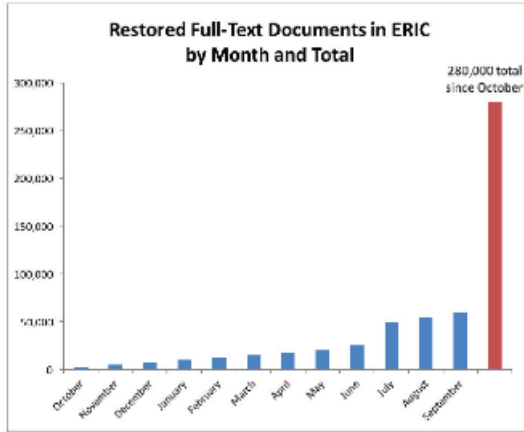
Data visualization concentrates on use of tables and graphs for presenting data, especially quantitative information, to the user and for the user to communicate with the data for better decision making. Media outlets and research organizations alike have invested in the production of data visualization, committing to the belief that visualization is an effective form of communication.

Dr David Tarrant of the Open Data Institute explains that the brain finds it easier to recognize and process patterns and trends than numbers, meaning products that visualize trends and patterns within data, as opposed to whole data sets, are more meaningful and accessible for audiences and can be understood more quickly than text and numbers [6].

"The purpose of visualization is insight, not pictures," according to computer scientist Ben Shneiderman. Data visualization creates a method through which ordinary people can better consume and understand large volumes of data. When data is properly visualized, patterns become obvious. Visualizations can help individuals quickly draw simple, actionable conclusions. The ideal state is for companies to spend less time compiling large volumes of data and leverage data visualizations to better identify and mitigate risks as well as proactively uncover valuable opportunities. Without data visualization, readers instead need to compile and compress the information on their own. Not only does this take more time and effort, but it can also lead different people to different conclusions [7].

The data visualization process works best when it is envisioned, implemented, and managed at an organizational level, rather than within a single department or by individual staff members. Regardless of the size of the organization, it is important to view data visualization as an initiative that will be carried out by a team from across all major data and reporting departments in the organization [8].

The terms "data visualization" and "infographic" or information graphic are often used interchangeably. While similar in concept, data visualizations are designed specifically to convey the meaning of datasets, whereas infographics are intended to help spread information about facts and opinions, as seen in Figure 1.



(1) Data Visualization



(2) Infographic

Figure 1: Data Visualization vs. Infographic

Data visualizations present larger amounts of data than infographics, which usually focus on only a few pieces of data. Data visualizations can be repurposed for other datasets, whereas infographics tend to be tailored to convey the meaning of a specific data value. The primary purpose of data visualization is to clarify the meaning of data with an emphasis of accuracy, on the other hand, an infographic displays a data-driven point or argument in a more compelling manner with aesthetic design. Big data will fundamentally alter education environment by implementing techniques and tailor the data to the precise needs of higher education institutions in a visualized format that will immensely improve the educational processes and decisions for the sake of the stakeholders.

3. Problem Statement

This research attempts to develop data analytics tool that provides a better Monitoring of HEI Performance, Enrolment and Graduates, and HEI Programs for a data-driven decision making with the following research questions:

What are the data elements needed in decision-making in terms of:

- a. Enrollment and Graduate Data
- b. HEI Programs
- c. Discipline
- d. Sex-Disaggregated Data

4. What are the features of CHED DataViz: A higher education data visualization tool of the Commission on Higher Education -Regional Office 1?

5. What is the level of software product quality of the CHED DataViz as to

- a. Functional Suitability

- b. Performance Efficiency
- c. Compatibility
- d. Usability
- e. Reliability
- f. Security
- g. Maintainability
- h. Portability

The significance of the Study

The developed CHED DataViz 1.0 will run on a cloud facility for faster processing. The data generated from CHED Electronic Collection and Knowledge System (CHECKS) is pre-processed to improve the data quality required for analysis and decision-making. Based on the collected data, it can facilitate an understanding of the role of big data in managerial decision making for the HEI, CHED Regional Offices and CHED Central Office in a visualized form. CHED DataViz 1.0 provides *Innovative Governance*, wherein the platform provides accurate and high-quality management information searching, filtering and reporting. To stay ahead in an increasingly data-driven world, the CHED DataViz 1.0 tool provides a better Monitoring of HEI Performance, Enrolment and Graduates, and HEI Programs for a data-driven decision making with Real-time Database and visualization of HEMIS data. In terms of accessibility, the data analytics tool enables efficient delivery of Higher Education Data, by providing access to HEIs.

6. Methodology

In this chapter, the methodology used in the study is described in the details. Included in the discussion are the details in identifying the data elements needed in the decision-making of the Commission on Higher Education and developing the data analytics tools including the information gathering and preprocessing of data.

The researcher will use the Systems Development Research Methodology which includes the following steps

1. Construct a conceptual framework by selecting a research objective that proposes a new way of doing things, based on the suggested new methods, techniques, or design.
2. Develop system architecture by providing a roadmap for the systems building process by placing the system components into perspective using the functional descriptions and structural relationships between the system components.
3. Analyze and design an information system which requires a thorough understanding of the studied

domain, and how to apply scientific and technical knowledge in creating, synthesizing and evaluating alternative solutions.

4. Build an information system that involves the application of software engineering principles in constructing a prototype to demonstrate the feasibility of the design and the usability of the functionalities requested.
5. Experiment, observe and evaluate the developed information system by testing its level of acceptability.

The study will be conducted at Commission on Higher Education - Regional Office 1 and total enumeration will be used to the administrative and technical division due to their manageable number of thirty-one (31); therefore, using any other techniques may not be necessary.

Instrumentation. To determine the level of satisfaction of the developed CHED Data Viz, the researcher utilized the USE Questionnaire by Lund (2001). Respondents will be asked to rate agreements with the statements, ranging from Strongly Disagree to Strongly Agree. "The questionnaires were constructed as five-point Likert rating scales. Users were asked to rate agreement with the statements, ranging from strongly disagree to strongly agree. Various forms of the questionnaires were used to evaluate user attitudes towards the CHED DataViz 1.0. The respondents were evaluating the products primarily using three dimensions, Usefulness, Satisfaction, and Ease of Use."

Data Analysis. Frequency counts and means are the primary statistical treatment to be used to analyze and interpret the survey results. The mean scores obtained along the different areas will be analyzed using the following scale of equivalents: 4.20- 5.00= "Strongly Agree," 3.40- 4.19= "Agree," 2.60- 3.39= "Neutral," 1.80- 2.59= "Disagree," 1.00- 1.79= "Strongly Disagree." The mean scores ranging from 2.60-5.00 indicate a high level of acceptability of the respondents which means that they accept and are ready with CHED DataViz 1.0 implementation. On the other hand, mean scores ranging from 1.00-2.59 indicate a low level of acceptability which means that respondents may not be ready to be introduced with CHED DataViz 1.0 application.

Systems Architecture. The CHED DataViz 1.0 was developed by implementing Model-View-Controller (MVC) programming technique using Code Igniter (CI) as a framework.

MVC is an architectural pattern usually used in web-based applications. It provides three main layers; model, view, and controller. Many developers use MVC as a standard design pattern. It is a complete framework that provide three types of classes: *Model classes* are used to implement the logic of data domains. These classes are used to retrieve, insert or update the data into the database associated with our application. *Views* are used to prepare the interface of our application. By using that interface users interact with our application. *Controller classes* are used to respond to the user's requests. Controller classes perform the users requested actions. These classes work with model classes and select the appropriate view that should be displayed to the user according to user requests [9].

According to the website of Code Igniter, CodeIgniter is a toolkit for people who build web applications using

PHP. Its goal is to enable programmers to develop projects much faster than they could by providing a rich set of libraries for commonly needed tasks, as well as a simple interface and logical structure to access these libraries. CodeIgniter lets the programmer creatively focus on a certain project by minimizing the amount of code needed for a given task. The following graphic illustrates how data flows throughout the system:

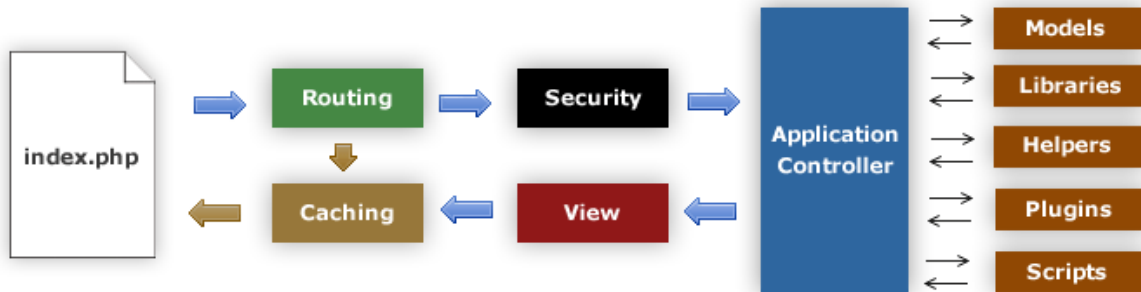


Figure 2: Application Flowchart of Code Igniter

The index.php serves as the front controller, initializing the base resources needed to run CodeIgniter. The Router examines the HTTP request to determine what should be done with it. If a cache file exists, it is sent directly to the browser, bypassing the normal system execution. Before the application controller is loaded, the HTTP request and any user submitted data is filtered for security. The Controller loads the model, core libraries, helpers, and any other resources needed to process the specific request. The finalized View is rendered then sent to the web browser to be seen. If caching is enabled, the view is cached first so that on subsequent requests it can be served [10].

7. Developed data analytics tool

The researcher worked on initial modules based on CHED Electronic Collection and Knowledge System (CHECKS) for both Regional and Central Offices. Upon entering the correct username and password will bring the user to the “Dashboard”. The functions which a user can access through the Dashboard will differ depending on the level of authority assigned to the user.

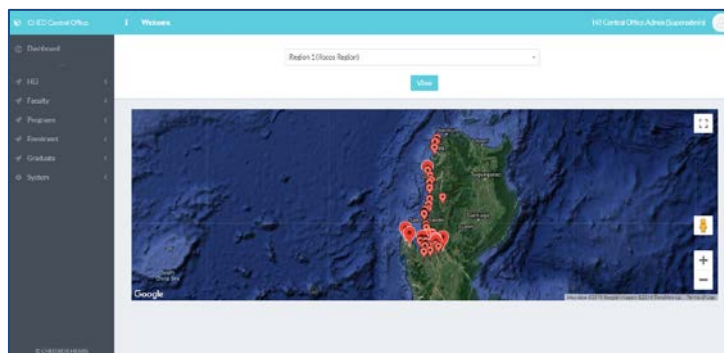


Figure 3: HEI Location Map per Region

The dashboard as seen on Fig. 3 displays a location map of every region. The right menu comprised of different modules such as HEI, Faculty, Programs (Program Search and Program by Region), Enrolment Data, Graduate Data and System Settings.

Figure 4 shows the enrolment module particularly the “Enrolment by Program”. The module displays a bar graph depicting the highest enrolment to lowest enrolment number per program. It can also display the enrolment by region, discipline, and congressional district. The same is also reflected in the Graduate module.

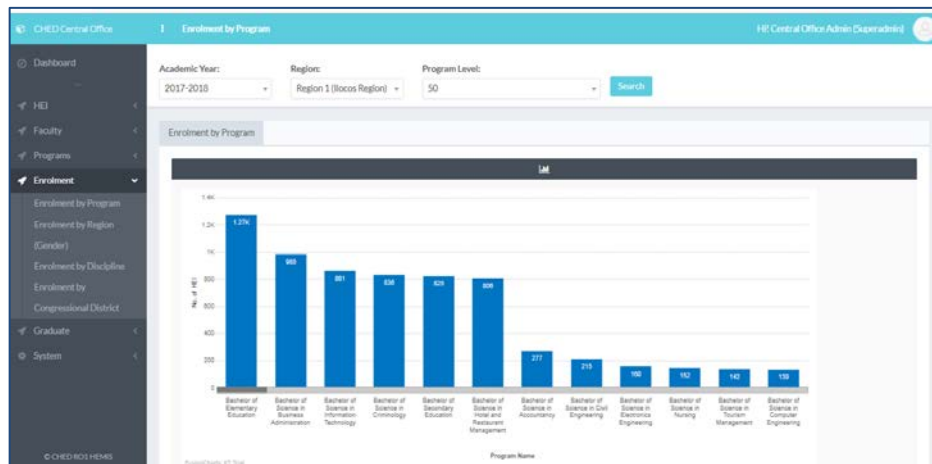


Figure 4: Enrolment Module (by program)

The availability of sex-disaggregated statistics in CHED DataViz 1.0 can lead to the development of policies and projects benefitting both men and women.

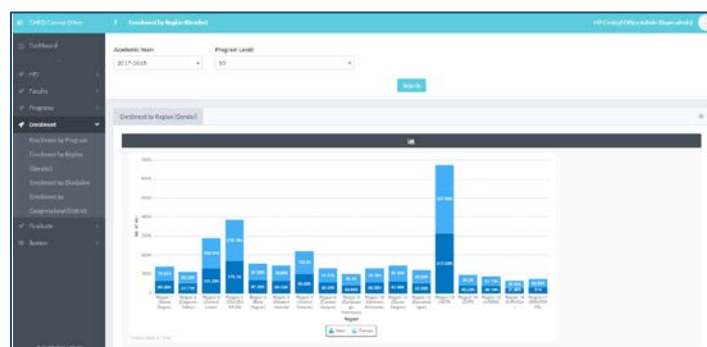


Figure 5: Enrolment Module (Sex-disaggregated)

By detecting trends in big data, it’s already possible to develop a contextual visual story and by presenting this data with the assistance of CHED Data Viz 1.0 — which can translate data and numbers into easy-to-grasp charts, graphs and visualizations.

8. Results and Discussions

ISO/IEC 25010 quality model has been adapted as a questionnaire to the respondents.

Functional Suitability. This characteristic represents the degree to which a product or system provides functions that meet stated and implied needs when used under specified conditions.

Table 1: Functional Suitability Evaluation

Functionality Suitability	Rating
Functional Completeness	4.77
Functional Correctness	4.51
Functional Appropriateness	4.87
Mean	4.72

As reflected in table 1, the respondents evaluated the criteria “Functionality Suitability” with a mean rating of 4.72 (strongly agree). The evaluation shows that CHED DataViz provides functions that meet the implied needs when used under specified conditions specifically the criteria “Functional Appropriateness” to which the functions facilitate the accomplishment of specified tasks and objectives Performance efficiency. This characteristic represents the performance relative to the amount of resources used under stated conditions.

Table 2: Performance Efficiency Evaluation

Performance Efficiency	Rating
Time Behaviour	4.77
Resource Utilization	4.65
Capacity	4.73
Mean	4.72

Table 2 shows, the respondents evaluated the criteria “Performance Efficiency Evaluation” with a mean rating of 4.72 (strongly agree) the evaluation shows that CHED DataViz met its stated functions in relation to the correctness and completeness with which respondents were able to utilize the tool in decision-making.

Table 3: Compatibility Evaluation

Compatibility	Rating
Co-existence	4.65
Interoperability	4.73
Mean	4.69

As reflected in table 3, the respondents evaluated the criteria “Compatibility” with a mean rating of 4.69 (strongly agree). The evaluation shows that the CHED DataViz met its stated functions as to the application can exchange information with other products, systems or components, and/or perform its essential functions, while sharing the same hardware or software environment. The criteria “Interoperability” was evaluated with a mean rating of 4.73. This explains that other CHED Higher Education Management Information System components can exchange information and use the information that has been exchanged.

Table 4: Usability Evaluation

Usability	Rating
Appropriateness Recognizability	4.90
Learnability	4.65
Operability	4.73
User Error Protection	4.77
User Interface Aesthetics	4.65
Accessibility	4.73
Mean	4.74

As stated in table 4, the respondents evaluated the criteria “Usability” with a mean rating of 4.74 (strongly agree). The evaluation shows that the criteria “Appropriateness recognizability” which described as “the degree to which users can recognize whether a product or system is appropriate for their needs” garnered the highest mean rating of 4.90.

Table 5: Reliability Evaluation

Reliability	Rating
Maturity	4.65
Availability	4.87
Fault Tolerance	4.70
Recoverability	4.65
Mean	4.72

Table 5 mentions that the respondents evaluated the criteria “Reliability” with a mean rating of 4.72 (strongly agree). The evaluation shows that CHED DataViz met the specified functions under specified conditions for a specified period of time, particularly the sub-criteria, “Availability”, which the tool is operational and accessible when required for use, 24/7. The tool is uploaded in a cloud platform so the users can access it anytime and anywhere.

Table 6: Security Evaluation

Security	
Confidentiality	4.65
Integrity	4.73
Non-repudiation	4.77
Authenticity	4.83
Accountability	4.65
Mean	4.72

Presented in Table 6, the respondents evaluated the criteria “Security” with a mean rating of 4.72 (strongly agree). The evaluation shows that the CHED DataViz met its stated functions as to the degree to which it protects information and data so that persons or other products or systems have the degree of data access appropriate to their types and levels of authorization. The tool that can be accessed through URL utilized a Secure Sockets Layer (SSL) that is used to encrypt the information on the Internet so that data can be transferred safely.

Table 7: Maintainability Evaluation

Maintainability	
Modularity	4.65
Reusability	4.73
Analysability	4.77
Modifiability	4.65
Testability	4.91
Mean	4.74

Shown in Table 7, the respondents evaluated the criteria “Maintainability” with a mean rating of 4.74 (strongly agree). The evaluation shows that the CHED DataViz can be modified to improve it, correct it or adapt it to changes in environment, and in requirements. Modifications can include corrections, improvements or adaptation of the software to changes in environment, and in requirements and functional specifications. Modifications include those carried out by specialized project technical staff, and those carried out by administrative and technical staff, or end users.

Table 8: Portability Evaluation

Portability	
Adaptability	4.77
Installability	4.78
Replaceability	4.75
Mean	4.77

Seen in Table 8, the respondents evaluated the criteria “Portability” with a mean rating of 4.5 (strongly agree). The evaluation shows that the CHED DataViz has the ability to run on any instance of the supported platform, including plug-compatible, virtual, outsourced or cloud-based environments.

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