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The Role of Big Data in Enhancing Innovation and Learning at Politeknik Sultan Salahuddin Abdul Aziz Shah (PSA)

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ABSTRACT – This study explores the transformative impact of big data initiatives on institutional management at Sultan Salahuddin Abdul Aziz Shah Polytechnic (PSA). By leveraging advanced data analytics and management techniques, PSA has enhanced decision-making processes, optimized resource allocation, and improved overall institutional performance. The study highlights the methodologies implemented, the challenges faced during the integration of big data solutions, and the outcomes achieved. Through a comprehensive analysis, this research demonstrates how big data can empower educational institutions to adapt to changing demands, foster innovation, and enhance the quality of education. The findings underscore the significance of data-driven strategies in promoting institutional effectiveness and sustainability.

KEYWORDS : Big Data, Institutional Management, Data Analytics, Decision-Making, Resource Allocation, Educational Innovation.

1.0 INTRODUCTION

In the digital era, Big Data has emerged as the 'new oil,' revolutionizing various sectors, including education. Educational institutions, such as Sultan Salahuddin Abdul Aziz Shah Polytechnic (PSA), are increasingly confronted with the complexities of managing diverse and disparate information systems. These challenges can hinder effective decision-making and operational efficiency. By leveraging Big Data initiatives, PSA can enhance its daily management processes and establish a robust framework for long-term strategic planning. The integration of Big Data into institutional management not only streamlines operations but also empowers educational leaders to make informed decisions based on comprehensive data analysis.

Thus, this research has been conducted to examine the transformative role of Big Data in enhancing institutional management at PSA by analysing the challenges encountered during its implementation and uncovering potential areas for improvement. Through a systematic examination of existing data practices and the implementation of advanced analytics, this study will provide actionable insights that can lead to more responsive and adaptive management strategies within the institution. By leveraging predictive analytics and data visualization tools, educational institutions can enhance their ability to anticipate trends, optimize resource allocation, and ultimately improve student outcomes. This research will also investigate the barriers to effective data utilization, ensuring that stakeholders are equipped with the necessary skills and resources to harness the full potential of Big Data in their decision-making processes.[1]

i. Big Data in Institutional management.

To further enhance the effectiveness of data integration within PSA, it is crucial to consider the implementation of a comprehensive big data governance framework. Such a framework not only addresses the technical aspects of unifying disparate data systems but also establishes policies and standards for data quality, security, and accessibility. By adopting best practices in data governance, institutions can mitigate risks associated with fragmented data management while fostering a culture that prioritizes data-driven decision-making among stakeholders [2].

Moreover, as educational environments become increasingly reliant on technology, there exists an imperative to invest in training programs that equip staff with the necessary skills to navigate and utilize these integrated systems effectively. This approach ensures that personnel are not merely passive consumers of data but active participants in leveraging insights for continuous institutional improvement, thereby aligning with strategic objectives and enhancing overall operational efficacy [3].

ii. Big Data Governance and Organizational Readiness.

To further advance the integration of big data within PSA, it is essential to explore not only the governance framework but also the role of advanced analytics in driving institutional effectiveness. By employing machine learning algorithms and artificial intelligence, educational institutions can enhance their predictive capabilities, allowing for more nuanced insights into student behaviour and resource utilization. This shift towards a data-informed culture necessitates ongoing investment in technology infrastructure as well as professional development for staff, ensuring they are equipped to leverage these tools effectively [3]. Additionally, embracing collaborative platforms that facilitate cross-departmental communication can foster an environment where data sharing becomes routine, ultimately leading to improved decision-making processes and operational strategies [2]. As such, the successful implementation of these initiatives will not only address current inefficiencies but also position PSA as a leader in innovative educational practices amidst the evolving landscape of higher education.

iii. Challenges and Opportunities in Big Data Initiatives

In addition to the implementation of advanced analytics, it is vital for PSA to cultivate a robust data governance culture that prioritizes ethical considerations surrounding data privacy and security. As institutions increasingly rely on vast datasets to inform their strategies, they must also navigate the complexities of compliance with regulations such as GDPR or local data protection laws, which can significantly impact how data is managed and utilized in educational settings.

Furthermore, fostering an environment where stakeholders understand the importance of data ethics not only enhances trust but also encourages responsible usage of information, ultimately leading to more effective decision-making processes [2] This proactive approach can mitigate potential risks associated with data breaches and misuse while promoting transparency within institutional operations. By aligning these ethical practices with technological advancements, PSA can ensure that its big data initiatives

contribute positively to both academic performance and institutional integrity, positioning itself as a forward-thinking leader in higher education management.

1.1 BACKGROUND OF THE STUDY

PSA offers a variety of TVET program that generate a large volume of data from separate systems such as SPMP, eSiS, HRMIS, MyKPI, CIDOS, and more. There is a critical need to unify these data sources centrally. Without an integrated system, audit processes such as MQA, ETAC, SIRIM, and TTAC become complex and time-consuming. Integrating these data systems will not only streamline audit processes but also enhance the overall efficiency of program management, allowing for more accurate assessments and timely interventions in student support services.

This integration will facilitate better data analysis, enabling stakeholders to make informed decisions based on comprehensive insights and trends derived from the unified dataset. By leveraging advanced data analytics tools and techniques, the unified system can also improve predictive modelling capabilities, ultimately leading to proactive measures that enhance student outcomes and institutional performance.

2.2 OBJECTIVES OF THE RESEARCH

The BigData@PSA Dashboard serves as a sophisticated tool designed for monitoring and operational analysis within the context of PSA operations. Its deployment is crucial for several reasons:

i. Data Integration : The dashboard integrates amounts of data from various sources within the PSA ecosystem.
ii. Real-time Monitoring : One of the primary functions of the dashboard is to provide real-time monitoring capabilities.
iii. Visualization Tools : The dashboard employs advanced visualization tools to present data in an intuitive format. Graphs, charts, and maps help users quickly grasp complex information, making it easier to identify patterns and insights that can drive operational improvements.
iv. Collaboration and Communication : The dashboard fosters collaboration among different departments within PSA. By providing a shared platform for data access and insights, teams can communicate more effectively and work together towards common operational goals.
v. Continuous Improvement : The insights gained from the BigData@PSA Dashboard contribute to a culture of continuous improvement.

In summary, the rollout of the BigData@PSA Dashboard is a significant and revolutionary milestone for the organization. This advanced platform is designed to leverage the power of big data analytics, providing stakeholders with in-depth insights and actionable data. By integrating vast datasets from various sources, the dashboard facilitates real-time monitoring and assessment of key performance metrics, enhancing decision-making across all organizational tiers [4]. Additionally, the BigData@PSA

Dashboard serves as a centralized platform for data visualization, allowing users to easily grasp complex data through intuitive graphical representations. This fosters a data-centric culture within the organization and empowers teams to identify trends, uncover hidden opportunities, and proactively address potential issues.

Essentially, the launch of this dashboard signifies a dedication to employing cutting-edge technology to improve operational efficiency, refine strategic planning, and ultimately enhance overall performance [5]. It positions the organization to stay competitive in a data-driven world, it improves monitoring, operational analysis and elevate overall service quality [6].

1.3 PROBLEM STATEMENT

In the continuously evolving domain of higher education administration, data has emerged as an indispensable resource for informed decision-making, strategic planning, and quality assurance protocols. As educational institutions actively engage in digital transformation initiatives, the dependence on a myriad of data systems has increased significantly. Nevertheless, this progress is accompanied by a range of challenges. Politeknik Sultan Salahuddin Abdul Aziz Shah (PSA), similar to numerous other educational entities, encounters considerable obstacles in the management of decentralized data sources that lack synchronization and uniform structure. Although these systems were initially developed to fulfil particular departmental requirements, the absence of integration has led to operational inefficiencies, particularly evident during audit procedures and institutional reporting processes. The following points clarify the key challenges that arise from this disjointed data environment:

i. Diverse systems are deployed to collect specific information or data, with each fulfilling its distinct objective [7]. For example, the Student Performance Management Program (SPMP) is tailored for students, while the Electronic Student Information System (eSiS) and Human Resource Management Information System (HRMIS) are engineered for personnel, among others. At times, these systems may exhibit overlapping functionalities with one another.

ii. During various audit processes, including but not limited to MQA, ETAC, TTAC, SIRIM, and financial audits, it was observed that there exists an absence of a centralized data repository that could be utilized to address the requests made by auditors. Consequently, the auditee is necessitated to conduct a manual search (via hardcopy) or to access each individual system separately in order to identify the requisite evidence for the auditor. The process of data verification can occasionally exhibit inconsistency or misalignment as a result of utilizing diverse data sources. This fragmentation not only prolongs the audit process but also increases the risk of errors, leading to potential compliance issues and undermining the overall integrity of the audit findings. [8]

iii. The acquisition of data for particular objectives frequently necessitates considerable time investment owing to a multitude of influencing factors. To address these challenges, organizations are increasingly turning to integrated auditing solutions that streamline data collection and enhance the accuracy of information retrieval [9]. These solutions leverage advanced technologies such as artificial intelligence and machine learning to automate data analysis, thereby reducing human error and expediting the audit process significantly.

2.0 METHODOLOGY

2.1 Research Design

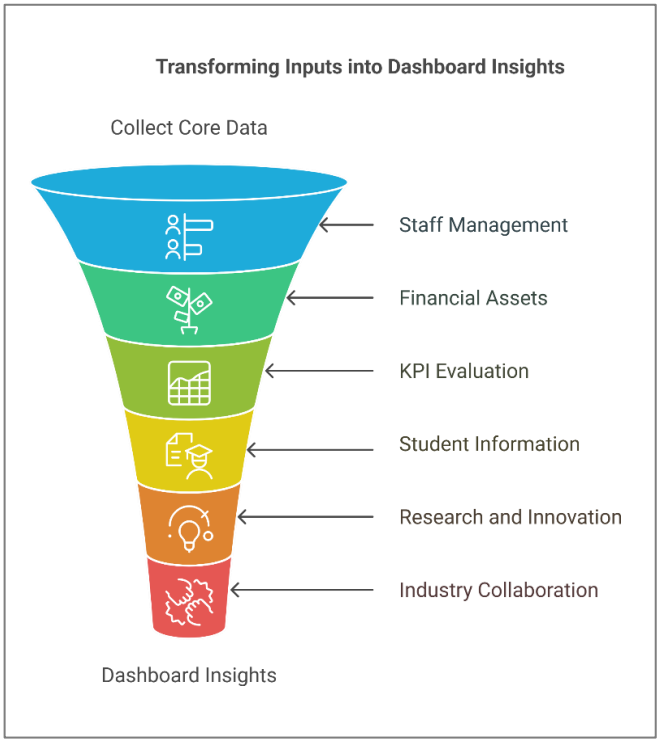

Figure 1: Big Data Transformation Funnel

The **Figure 1** illustrates how core data collected from various institutional functions is transformed into valuable insights through a centralized dashboard system.

Top of the Funnel : Accumulation of Fundamental Data: This particular stage is characterized by the systematic and comprehensive gathering of essential data that is crucially derived from a variety of vital operational domains that underpin the overall functioning of the organization:

i. Staff Management – This encompasses detailed information related to the number of personnel employed, their educational backgrounds, individual performance evaluations, as well as the lengths of their respective tenures with the organization.
ii. Financial Assets – This includes a thorough collection of data that pertains to the ownership of various financial assets along with a range of important financial metrics that reflect the organization's fiscal health.

iii. KPI Evaluation – This involves an assessment of the current Key Performance Indicators, which are meticulously derived from established systems such as Persist that track and evaluate performance over time.
iv. Student Information – This refers to the comprehensive documentation of student engagement levels, notable accomplishments, and the certifications attained by the students throughout their academic journey.
v. Research and Innovation – This category includes data that illustrates the output of research activities as well as the contributions to innovation made by both staff and students alike, highlighting the collaborative efforts in advancing knowledge.
vi. Industry Collaboration – This encompasses the collection of information related to various training initiatives, strategic partnerships formed with industry stakeholders, and tracer investigations that assess the effectiveness of these collaborations in the real world.

Bottom of the Funnel : Dashboard Insights: Every single piece of aggregated data that has been collected from various sources and channels goes through a thorough process of meticulous analysis, visualization, and presentation within the confines of the Dashboard interface, which ultimately facilitates the following outcomes: Real-time surveillance that allows for constant monitoring of key metrics and performance indicators, Informed decision-making that is based on a comprehensive understanding of the data at hand, and Strategic planning that is predicated on the availability of cohesive, precise, and timely information that can be relied upon to guide future actions and initiatives.

2.2 Development Phases

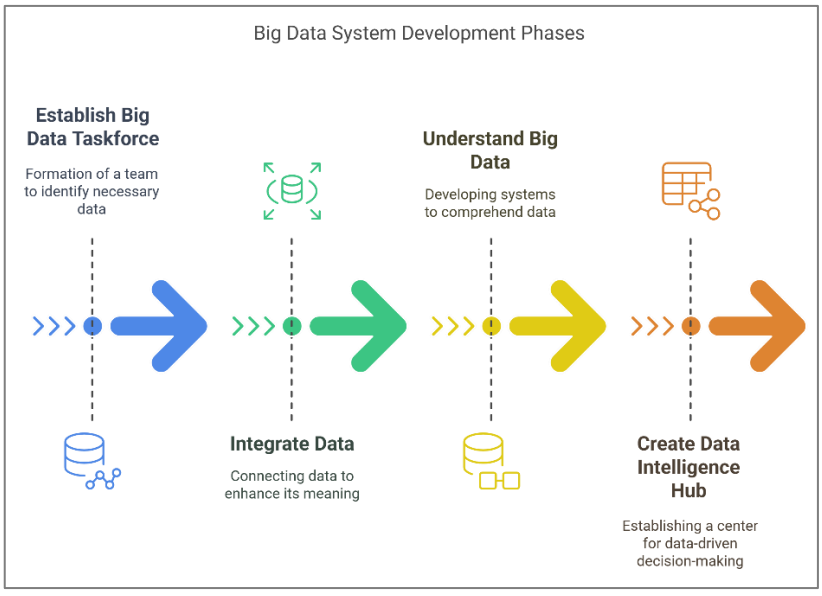

Figure. 2: Big Data System Development Phases Diagram

The design of the Bigdata@PSA system (Figure 2) is divided into four key stages. Phase 1 – Input Data commences with the inception of the Big Data Taskforce, which is assigned the essential responsibility of identifying and delineating the requisite data to be

incorporated into the system. Subsequently, Phase 2 – Integrated encompasses the amalgamation of diverse data sets to guarantee that the information attains greater interconnectivity and significance for particular operational processes. Advancing further, Phase 3 – Knowledge signifies the commencement of system development and reconfiguration initiatives at PSA, with the objective of cultivating a comprehensive understanding of the data pertinent to each criterion, thereby ensuring that the resultant output data can be employed effectively and meaningfully. Ultimately, Phase 4 – Intelligent evolves the system into a knowledge repository, facilitating the discernment of suitable actions to be undertaken based on the insights extracted from the generated data. This progression not only enhances decision-making capabilities but also fosters a culture of continuous improvement and innovation within the organization.

2.3 Data Analysis Techniques

Data analysis, which is a critical process for understanding and interpreting complex sets of information, can be effectively performed using the powerful tools and capabilities offered by Microsoft Power BI, a business analytics service that provides interactive visualizations and business intelligence capabilities with a user-friendly interface designed to facilitate the exploration and manipulation of data [10]. These features enable organizations to transform raw data into actionable insights, empowering teams to make informed decisions and drive strategic initiatives forward. By leveraging Power BI's advanced analytics features, such as real-time dashboards and custom reporting options, organizations can gain deeper visibility into their performance metrics and operational efficiencies.

2.4 Anticipated Benefits for PSA

Furthermore, as PSA continues to refine its data governance framework through the implementation of the Bigdata@PSA Dashboard, it is crucial to consider the role of emerging technologies in enhancing educational outcomes and operational efficiencies. By integrating artificial intelligence (AI) and machine learning algorithms into the dashboard's analytics capabilities, PSA can unlock deeper insights from its datasets, enabling predictive modelling that anticipates student needs and institutional challenges before they arise [11]. Such proactive measures not only improve resource allocation but also foster a more personalized learning environment for students, aligning with global trends towards tailored educational experiences. Additionally, by embracing real-time data processing, PSA can enhance its responsiveness to changing circumstances, thereby solidifying its position as an innovative leader within the Technical and Vocational Education and Training (TVET) landscape. This strategic integration of technology will ultimately empower stakeholders across all levels to engage more effectively with data, driving continuous improvement and reinforcing a culture of excellence throughout the institution.

2.5 Contribution to the Field of Institutional Management

As PSA embraces these technological advancements, it is essential to consider the ethical implications surrounding data usage and stakeholder engagement. The integration of AI and machine learning must be accompanied by a robust framework that ensures transparency and accountability in how student information is collected and analysed. This aligns with findings from recent studies emphasizing the importance of stakeholder-centric approaches in data ethics, which advocate for genuine involvement of all parties affected by data practices [12]. Moreover, as PSA advances its data governance initiatives through the Bigdata@PSA Dashboard, it is imperative to consider how collaboration with industry stakeholders can further enrich the educational ecosystem. By establishing strategic partnerships that leverage real-world insights and feedback, PSA can ensure that its programs are not only aligned with current market demands but also responsive to future trends in workforce requirements. This collaborative approach mirrors successful models observed in other sectors, such as Performance Based Logistics (PBL), where high- quality information about operational needs significantly enhances decision-making processes [13]. Furthermore, integrating stakeholder input into the dashboard's analytics could foster a more inclusive environment, encouraging diverse perspectives that drive innovation and improve overall program relevance.

3.0 RESULT

3.1 IMPLICATIONS OF FINDINGS

Figure 3: Bigdata@PSA Dashboard Diagram

Politeknik Sultan Salahuddin Abdul Aziz Shah (PSA) has conceptualized and executed a centralized dashboard system referred to as Bigdata@PSA, with the aim of augmenting data governance, operational efficacy, and institutional transparency. This dashboard functions as a robust institutional instrument engineered to optimize and visualize fundamental operational data across diverse functional domains within PSA. It consolidates essential information, such as recognitions for innovation, utilization of facilities and buildings, allocation of assets, performance in student entrepreneurship, outcomes of academic programmers, and statistics related to graduate employability into

a coherent, interactive platform. In so doing, it eradicates data silos and facilitates stakeholders in accessing real-time, precise, and relevant insights at their convenience [14].

Moreover, the dashboard underpins evidence-based decision-making, especially in the contexts of strategic planning, quality assurance assessments (e.g., MQA, ETAC), and performance evaluation. Through the application of dynamic visual analytics, users are afforded the opportunity to readily monitor institutional advancement, discern discrepancies, and suggest timely remedial actions. This initiative concurrently diminishes reliance on manual reporting processes, bolsters transparency, and heightens responsiveness during both internal and external evaluations. In summary, the PSA centralized dashboard transcends the conventional utility of a reporting tool— it embodies a digital transformation initiative that empowers departments to collaborate, nurtures a culture of data-driven excellence, and positions PSA at the vanguard of innovation within the Malaysian Technical and Vocational Education and Training (TVET) ecosystem [15].

However, several significant obstacles were faced during the implementation phase. A primary concern was the challenge of harmonizing data collected from diverse systems because of differences in formats. The task of obtaining precise and current data from each department or assigned data steward was also lengthy and required extensive teamwork across various units. In addition, setbacks in project delivery were unavoidable, especially when data from specific departments or crucial personnel were incomplete or inconsistent. Another important challenge was coordinating staff from different departments with varying priorities, as it proved difficult for some individuals to fully engage due to the demands of their regular duties and other urgent obligations. Effective communication and regular check-ins among team members became essential to navigate these obstacles, ensuring that everyone remained aligned on project goals and deadlines while fostering a collaborative environment.

4.0 CONCLUSION

In conclusion, this research proposal on empowering institutional management through Big Data initiatives at Sultan Salahuddin Abdul Aziz Shah Polytechnic (PSA) outlines a comprehensive strategy to address the challenges posed by fragmented data systems within educational institutions. By integrating Big Data practices, PSA aims to enhance decision-making processes, operational efficiency, and long-term strategic planning. This approach not only promises to improve the institution's overall performance but also positions PSA as a leader in leveraging technology for educational advancement, ultimately benefiting students and staff alike.

The proposed Bigdata@PSA Dashboard serves as a pivotal tool for real-time monitoring and operational analysis, enabling stakeholders to access and utilize data effectively. Furthermore, the emphasis on data governance, advanced analytics, and ethical considerations ensures that the institution not only complies with regulatory standards but also fosters a culture of data-driven decision-making. The anticipated benefits include improved student outcomes, optimized resource allocation, and a proactive approach to institutional challenges. Ultimately, this research contributes to the

evolving field of institutional management by highlighting the transformative potential of Big Data in education, positioning PSA as a leader in innovative practices within the Technical and Vocational Education and Training (TVET) landscape.

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