

The Role of the Data Management Centre for Data Sustainability at Academic University for: Literature Review

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Abstract

Informed *decision-making* is increasingly recognised as a standard for policymaking in many fields, including academia and universities. However, many challenges exist in identifying the appropriate evidence, disseminating it to different stakeholders, and implementing it in various settings. Academic universities brought together international experts and stakeholders to increase knowledge in the field of evidence-informed policy, develop a research agenda, strengthen international collaborations, and create a community for sharing experience, research, and best practices. Consequently, the effects of all this new smart dashboard insight are not fully realized. It is imperative to develop a system that can collect, integrate, manage, and analyse on- and off-farm *data in real time* for practical and relevant actions.

Purpose: The University Data Management Centre (UDMC) has been called a "ground-breaking" area for university strategy, and it is among the top future trends for academic universities. Hence, this study aims to systematically review UDMC practices and services, primarily focusing on the challenges, services, and skills along with motivational factors associated with them.

Design/methodology/approach – A systematic literature review method was used, focusing on literature produced between 2015 and 2022 to understand the latest trends.

Findings: The role of the University Data Management Centre is gradually gaining importance among staff and academic universities; however, it is still poorly practised. Albeit, it is better observed in developed countries than developing countries; however, there are lots of challenges associated with UDMC practices by top managers and strategic universities. These challenges demand certain sets of skills be developed for better practices and services. Active

collaboration is required among stakeholders and university registrar departments to figure out the challenges and issues.

Research limitations and implications: The implications of policy and practical points of view present how impact university data can be better managed in the future by CDOs and university professionals. The expected or desired role of key stockholders in this regard is also highlighted.

Originality and value: UDMC is an important and emerging area. The registrar and top managers are not comprehensively managing university data, as it involves complex cooperation among various stakeholders. A combination of measures is required to better manage university data, which would ultimately lead to a data-driven culture in decision-making.

Keywords: Research Data management, Research Data Management Practices, Research Data Services, Systematic Literature Review.

Paper Type: Literature Review

Introduction

Data-driven decision-making has become increasingly crucial in various sectors and industries. This includes the field of higher education, where universities are faced with numerous challenges and complexities in decision-making. One of the challenges faced by universities is ensuring student academic performance and success. Research has shown that universities can improve decision-making and student academic performance through the use of data warehousing and data mining (Santoso, 2018). Data warehousing allows universities to store and organize vast amounts of data related to student performance, including grades, attendance records, and course evaluations. By analyzing this data, universities can identify patterns and trends that may impact students' academic success.

This information can then be used to make informed decisions and interventions, such as identifying at-risk students who may benefit from additional support or resources. Another area where data-driven decision-making is crucial in universities is in the development and implementation of decision support systems. These systems provide universities with a framework for making complex decisions, such as selecting study programmes or allocating resources. By utilising data mining techniques, universities can extract valuable insights from various sources of data, such as student preferences, enrolment trends, and faculty expertise. These insights can help inform the development of effective decision support systems that align with the needs and preferences of students, faculty, and staff. Furthermore, data-driven decision-making can also help universities enhance the overall educational experience and services for students, researchers, and staff. By analysing data on student preferences and feedback, universities can tailor their products and services to better meet the needs of their stakeholders (Gan & Jie, 2022). For example, by analysing data from student satisfaction surveys or course evaluations, universities can identify areas for improvement in teaching methods or curriculum design. Additionally, data-driven decision-making can aid in the identification of trends and patterns that may inform strategic planning and resource allocation.

Literature Review

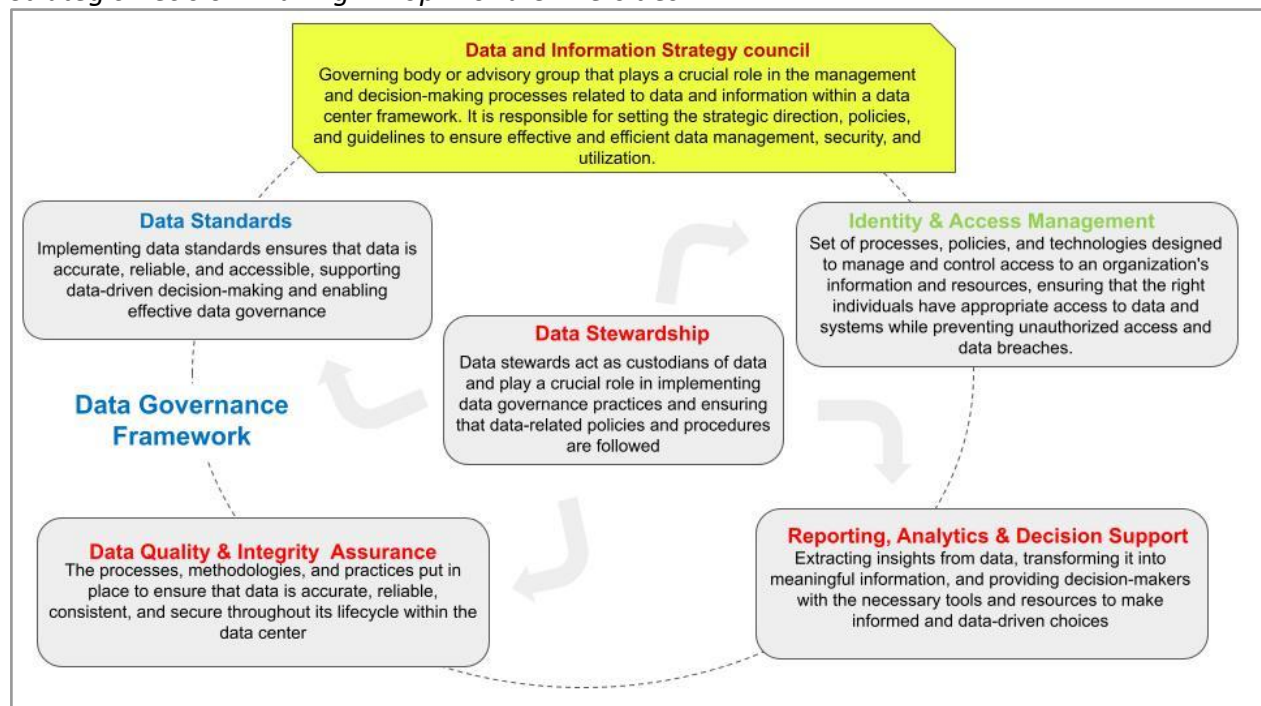
Strategic Decision-Making in Top World Universities

Figure 1: Data Governance Framework

In today's competitive global landscape, top world universities must continuously adapt to changing circumstances and make strategic decisions that align with their mission, vision, and values. Universities must continuously adapt to changing circumstances and make strategic decisions that align with their mission, vision, and values to remain successful and relevant. The importance of strategic planning in higher education institutions is increasing as the procedures performed in a university become more complicated. Strategic planning in universities involves a comprehensive process that includes setting goals and objectives, developing work plans, allocating resources based on priorities, and employing participative management approaches to ensure that all stakeholders are involved in decision-making (Owan & Offu, 2021).

By utilising strategic planning methods, senior management and middle managers are able to align their daily activities with the broader goals of the institution. (Charbel, 2019) This approach fosters data-based decision-making, as strategic planning provides a framework for analysing relevant information and trends in order to make informed choices. Moreover, strategic planning creates the foundation for performance measurement, allowing universities to monitor progress towards their goals and allocate resources accordingly. Furthermore, strategic planning helps universities navigate through the increasingly competitive landscape of higher education. In order to predict decision-making and envision strategies for the future, top universities employ various approaches and tools. A common use is analysing data and conducting trend analysis.

This involves gathering and analysing data on various factors such as student enrolment, financial resources, market trends, technological advancements, and demographic changes. By examining this data, universities can identify patterns and trends that may impact their decision-making. They can use this information to make informed decisions about enrolment strategies, programme offerings, resource allocation, and other strategic initiatives. Another

approach used by top world universities in predicting decision-making and envisioning strategies for the future is scenario planning. Scenario planning involves imagining different possible future scenarios and developing strategies to address each one.

This approach allows universities to proactively prepare for potential challenges and capitalise on emerging opportunities. In addition, top world universities often engage in strategic foresight exercises to anticipate future trends and developments in the higher education landscape. These exercises involve analysing global and regional trends, conducting stakeholder consultations, and engaging in foresight tools such as environmental scanning and trend analysis (Bonsu et al., 2020). Strategic foresight exercises enable universities to identify emerging trends and challenges that may impact their decision-making in the future. Overall, top world universities employ a combination of data analysis, scenario planning, and strategic foresight exercises to predict decision-making and envision strategies for the future of higher education. In doing so, they aim to not only stay ahead of the curve but also maintain their competitive advantage in a rapidly evolving global higher education landscape. In order to predict decision-making and envision strategies for the future, top universities around the world rely on a variety of approaches and tools. These approaches include analysing data and conducting trend analysis, scenario planning, and strategic foresight exercises. By analysing data and conducting trend analysis, universities can gather information on various factors that may impact their decision-making. This includes market trends, technological advancements, and demographic changes. This information allows universities to identify patterns and trends that may impact their decision-making (Albreiki et al., 2021).

This data-driven approach enables universities to make informed decisions about enrollment strategies, program offerings, resource allocation, and other strategic initiatives. Additionally, scenario planning plays a crucial role in predicting decision-making and envisioning strategies for the future. Scenario planning involves imagining different possible future scenarios and developing strategies to address each scenario (Griffin, 2018). Data-driven decision-making is an essential component of effective financial strategy in university enrollment. With the expansion of enrollment in colleges and universities, there has been a correspondingly explosive growth in financial data (Chu et al., 2022). As the enrollment scale of colleges and universities is expanding, the financial data of these institutions also experience significant growth. This data comprises various elements such as enrollment numbers, revenue sources, expenditure details, and financial aid information. To ensure effective financial management and decision-making, it is crucial to mine this data for valuable insights and apply them appropriately (Zhao, H. 2022). In the field of college management research, current focus is on using intelligent algorithms to analyze and interpret this vast amount of data. The advent of the information age and the rapid development of computer technology and information technology have facilitated this process. Data-driven decision-making in university enrollment financial strategy involves utilizing internal data such as administrative records, financial records, enrollment data, student information, and faculty records that are stored and processed in-house through data warehousing.

Decision-Making Using University Data

The use of university data for decision-making poses several challenges that can affect the accuracy and effectiveness of the decisions made. These challenges can be categorized into technical and organizational challenges (Munshi & Alhindi, 2021). From a technical standpoint, one of the challenges is the capability of the infrastructure at universities to process and handle the large volumes of data being generated (Munshi & Alhindi, 2021). This includes the ability to effectively store, access, and analyze the data in a timely manner.

Another technical challenge is the ability to monitor the impact of decisions made based on university data. This requires the implementation of mechanisms and tools for tracking and assessing the outcomes of decisions, as well as evaluating whether they align with stated objectives.

From an organizational perspective, the absence of a comprehensive platform tailored for educational organizations can hinder the gathering and analysis of data effectively. This can make it difficult for decision-makers to access and interpret the data they need in a meaningful way. Furthermore, the deployment and use of technologies for data collection and analysis can pose challenges (West et al., 2020). This includes ensuring that the technologies are compatible with existing systems and processes, as well as adequately trained staff to utilize these technologies effectively (Li, 2021). Overall, the challenges in using university data for decision-making arise from technical limitations in infrastructure and monitoring capabilities, as well as organizational obstacles such as the lack of a comprehensive platform and difficulties in deploying and using technologies (Munshi & Alhindi, 2021).

Challenges with University Data

As educational institutions increasingly rely on data for decision-making, the management of university data has become a significant challenge. The expansion of legitimate educational interests has led institutions to collect a vast amount of data, resulting in exponential data warehouses. For example, institutions like Arizona State University are grappling with the complexities of managing and utilising this data effectively (Bae et al., 2016).

The use of enterprise-level data warehouses, which house data for various users with legitimate educational interests, poses challenges for universities. These challenges include data production, archiving, analysis, and the transition towards a data-driven culture. The sheer volume of data being collected makes it difficult for universities to effectively manage and utilise it. Centralising and standardising university data in common formats is necessary to overcome this challenge (Jiang & Zhang, 2022).

Centralising university data is a manageable challenge that requires careful planning and implementation. It is crucial to collect data and develop and utilise it effectively (Falola et al., 2018). By utilising big data collection and analysis, universities can promote the construction of educational management information systems that make better use of information equipment (Li, 2021).

This, in turn, can improve the overall level of college education management. However, using big data at universities also presents limitations and challenges. One major challenge is ensuring data quality. Data quality, accuracy, completeness, and availability are major hurdles to using large datasets. Inaccurate data can lead to flawed analysis and biased inferences, which can have detrimental effects on decision-making. Furthermore, the management and storage of large amounts of data also present challenges related to maintaining data security, accuracy over time, archiving data, managing data warehouses, and disposing of information. The sensitivity and confidentiality of the data stored in university data warehouses further add to the management challenges. Furthermore, the sensitive nature of the data stored in university data warehouses adds to the management challenges (Renanita & Himam, 2020). The sensitive data stored in university data warehouses, such as financial transactions, medical procedures, insurance claims, diagnosis codes, and personal information, requires strict access controls and rigorous data governance to ensure privacy and compliance with regulations. In conclusion, university data warehouses pose significant challenges for institutions in managing and utilising the exponential volume of data being collected. These

challenges include ensuring data quality, maintaining data security and accuracy over time, managing data warehouses, and disposing of information.

One possible solution to address these challenges is to centralise university data in common formats. Centralising university data in common formats can help mitigate the challenges associated with data quality, security, and management. Centralising the data allows for better governance and control over its quality, ensuring that it is accurate, complete, and available when needed (Cavus et al., 2022). Additionally, centralising university data can facilitate more efficient and effective analysis, as it allows for easier integration and comparison of data from different sources. This can help in identifying patterns, trends, and insights that can inform decision-making processes (Falola et al., 2018).

University Data Strategy

In today's data-driven world, universities are increasingly recognising the value of using data to inform decision-making processes. By incorporating data analytics into their operations, universities can improve their operational efficiencies, support evidence-based decision-making, and drive growth. In fact, research shows that 70% of senior business executives believe that incorporating data analytics is crucial for sustaining and improving competitiveness in the higher education sector (Albreiki et al., 2021).

One of the key areas where data analytics can have a disruptive impact is in business education. As the technology industry evolves at a rapid pace, academia faces challenges keeping up with the advancements in data analytics. To address this challenge, universities must adopt an innovative and adaptable curriculum that addresses multiple levels of data analysis. This means incorporating courses and programmes that teach students how to collect, analyse, and interpret data in a business context (Krishna & Aithal, 2023).

By equipping students with the necessary skills and knowledge in data analytics, universities can prepare them for the demands of the modern business landscape. Furthermore, universities can utilise data analytics to improve student outcomes and enhance the overall learning experience. For example, through learning analytics, universities can gather and analyse data on student performance and engagement to identify areas where support is needed. They can also use data analytics to personalise instruction and provide targeted interventions for students who may be struggling (Parkin, 2022). Furthermore, the use of data analytics in education allows for the discovery of valuable insights that can inform institutional decision-making. For instance, universities can analyse data on student enrollment patterns to identify trends and develop targeted recruitment strategies. Additionally, data analytics can be used to assess the effectiveness of various academic program and initiatives, enabling universities to make informed decisions on resource allocation and programme development to better meet the needs of their students and stakeholders.

Overall, the integration of data analytics into higher education institutions can have significant benefits. It can improve learning, transform the university, increase organisational productivity and effectiveness, and help understand the institution's successes and challenges. The data-driven strategy for universities in decision-making envisions the adoption of analytics as a crucial tool for sustaining and improving competitiveness in the higher education sector (Fijałkowska et al., 2018).

In today's digital era, universities are faced with the challenge of managing and utilising vast amounts of data to support their academic mission. The implementation of a data management centre and the appointment of a chief data officer are essential to effectively addressing this challenge. The role of a chief data officer in higher education management is relatively new, but rapidly growing. The emergence of this leadership position underscores

the crucial need for universities and colleges to have dedicated individuals who can oversee and coordinate data management efforts across faculty and administration in higher education institutions. The implementation of a data management centre at a university can provide centralised support and resources for managing, analysing, and utilising the vast amounts of data generated within the institution. A data management centre would serve as a hub for data-related activities, including data collection, storage, integration, and analysis. Furthermore, a data management centre can facilitate collaboration and knowledge sharing among different departments and units within the university. The Chief Data Officer, as a senior managerial role, would ensure that the data management centre operates efficiently and effectively. They would be responsible for developing and implementing data management strategies, policies, and procedures that align with the goals and objectives of the university (Chu et al., 2022). Additionally, the Chief Data Officer would work closely with other senior leaders, such as the Chief Information Officer and the Chief Service Officer, to ensure that data is effectively utilised to support decision-making and enhance the overall efficiency and effectiveness of university operations.

The implementation of a data management centre and the appointment of a chief data officer would bring several benefits to universities. Firstly, it would enhance data governance and ensure that the university has a clear and consistent framework for managing its data assets. This includes defining data ownership, roles and responsibilities, data quality standards, and data privacy policies. Secondly, having a data management centre and Chief Data Officer in place would enable the university to better leverage its data for strategic decision-making. The Chief Data Officer would have the expertise and knowledge to identify meaningful insights from data and provide actionable recommendations to senior leaders. Additionally, the data management centre and Chief Data Officer would play a crucial role in promoting data-driven innovation within the university.

They would actively seek opportunities to use data analytics and insights to drive innovation in teaching, research, and administrative processes. Furthermore, the implementation of a data management centre and Chief Data Officer would lead to improved collaboration and coordination across different departments within the university. This would facilitate the sharing of data and knowledge, allowing different units to gain insights from each other's data and make more informed decisions (Rossi & Hirma, 2022).

Findings



Figure 2: Role of UDMC

The role of university data management centres in universities is becoming increasingly important for effective decision-making and strategic planning. However, the implementation of UDMC practices is still lacking, particularly in developing countries. This is due to several challenges that top managers and universities face in implementing UDMC practices, which require the development of certain skills for better services. One of the main challenges in implementing UDMC practices is the task of analysing information. The task of analysing information in higher education institutions is currently challenging, mainly due to two factors (Moscoso-Zea et al., 2019). Firstly, higher education institutions have a vast amount of data stored in their databases relating to student information (Hamoud et al., 2018). This data includes various aspects such as student demographics, academic performance, and enrollment history. Secondly, the data sets are often complex and heterogeneous, coming from various sources and in different formats. Therefore, the challenge lies in effectively analysing and integrating this data to derive meaningful insights and make informed decisions.

Another challenge in UDMC practices is the need for skilled personnel. To overcome these challenges, universities must prioritise the development of certain skills among their staff and top managers. These skills include data analysis, data mining, and knowledge management. Data analysis skills are essential for effectively analysing the vast amount of data available in university databases. Data mining skills are necessary for transforming raw data into usable knowledge and information. Furthermore, knowledge management skills are crucial for organising and managing the derived insights in a way that facilitates decision-making processes. Additionally, universities need to invest in technology and infrastructure that support UDMC practices. This includes implementing appropriate data management systems, data mining tools, and analytics platforms that enable efficient storage, retrieval, and analysis of data. Furthermore, universities should also foster a culture of data-driven decision-making and encourage collaboration between different departments and stakeholders.

Moreover, the application of data mining methods in educational institutions has gained momentum in recent years. This is evident from the increasing research interest in applying

data mining techniques in the educational sector. This trend has led to the emergence of a new term called educational data mining, which focuses on utilising data mining methods specifically for educational purposes. Education data mining aims to gain new knowledge and insights about the behaviour of students, educators, administrators, and university staff (Wang, 2022).

Furthermore, data mining in higher education can strategically combine institutional data and statistical analysis to generate information that can be used by students, educators, administrators, and management to improve practices (Zhao, 2022). By utilising data mining techniques, universities can uncover hidden patterns, trends, and relationships within their data. These insights can inform decision-making processes, leading to more effective strategies and policies. For example, data mining can be used to identify factors that contribute to student success or retention rates, allowing universities to implement targeted interventions and support systems (Yin, 2016).

In addition to improving decision-making processes, data mining in universities can also contribute to enhancing academic quality assurance. By effectively managing and analysing data, universities can identify areas for improvement and take proactive measures to ensure the quality of education. This may include identifying gaps in curricula, evaluating the effectiveness of teaching methods, and assessing the impact of university policies on student outcomes (Regueras et al., 2019).

To effectively harness the potential of data mining in university settings, top managers and strategic leaders must address certain challenges and develop specific skills. These challenges include data privacy and security concerns, ensuring data accuracy and reliability, integrating different data sources from various departments, implementing appropriate data mining algorithms, and interpreting and effectively communicating the findings derived from data mining analysis (Tarnate & Devaraj, 2019).

In order to tackle these challenges, top managers and strategic leaders in universities must develop skills in data management, data analysis, and data visualization. They need to be proficient in data governance and ensuring compliance with privacy regulations. Furthermore, they should have a strong understanding of statistical techniques and data mining algorithms to effectively analyse the data (Saheed et al., 2018).

Conclusion

In conclusion, the fast-paced nature of the technology industry presents challenges for academia to keep up with advancements in data analytics. To address these challenges, universities should embrace innovation and adapt their curricula to incorporate multiple levels of data analysis. By doing so, it allows for a comprehensive analysis of various factors that impact enrolment, university strategy, vision, mission, and financial outcomes. Universities can equip staff with the necessary skills for success in the data-driven business world, and also utilise data analytics to enhance university outcomes and the overall learning experience. Overall, the implementation of a data management centre and the appointment of a Chief Data Officer in universities are crucial to ensuring effective data governance, enhancing decision-making processes, promoting innovation, and fostering collaboration.

Theoretical and Contextual Contribution of Research

The data management center at an academic university plays a crucial role in the theoretical and contextual contribution of this research. It serves as a centralized hub for the organization, storage, analysis, and dissemination of research data generated by faculty

members, researchers, and students. By offering specialized data management services and resources, the data management center enhances the rigor and validity of academic research while also promoting collaboration, transparency, and reproducibility. One of the key contributions of the data management center is its role in ensuring standardized data management practices. Individual researchers may have varying data management practices, leading to inconsistencies and potential difficulties in comparing and replicating research findings. The data management center helps address this issue by providing guidelines, tools, and support for researchers to properly manage their data throughout the research lifecycle. Furthermore, the data management center plays a vital role in preserving research data for future use. It establishes protocols for data storage, backup, and retention, ensuring that research data is securely stored and accessible in the long term. Additionally, the data management center facilitates data sharing and collaboration among researchers. It provides a platform for researchers to securely share their data with other members of the academic community, fostering collaboration and enabling the replication and validation of research findings. Furthermore, the data management center can contribute to the contextual understanding of research by promoting data transparency and openness. By implementing open data policies and practices, the data management center enables researchers to openly share their data, methods, and findings, allowing others to scrutinize and build upon the research. This promotes transparency, accountability, and the advancement of knowledge within the academic community. The data management center also plays a pivotal role in supporting the integration of multidimensional datasets in laboratory medicine research. It ensures that research data from different sources and in various formats can be integrated and analyzed effectively, enabling a comprehensive understanding of complex medical phenomena. Overall, the theoretical and contextual contribution of a data management center at an academic university is significant. It supports the standardization of data management practices, promotes collaboration and transparency, facilitates data sharing and preservation, and enables the integration of multidimensional datasets. In conclusion, the Data Management Center at an academic university contributes significantly to the theoretical and contextual aspects of research.

Sustainability Elements in Developing a University Data Management Center

Developing a sustainable university data management centre involves considering various elements. Some key elements of sustainability to consider in the development of a university data management centre include training for sustainable data management best practices, the role of the university in society and the health and lifelong learning of employees and students, the promotion of equity and social justice, waste management planning, and the implementation of green technology and infrastructure. Additionally, the integration of sustainability into the university's curriculum, research agenda, and community services is essential for a sustainable data management centre. Furthermore, the centre should prioritize energy and resource conservation, waste reduction, and efficient environmental management to ensure a healthy campus environment. In order to develop a sustainable university data management centre, it is important to consider the various elements that contribute to sustainability.

Furthermore, promoting sustainability in teaching and research is another key aspect of developing a sustainable university data management centre. This involves integrating sustainability concepts and practices into the curriculum, conducting research on sustainable

data management strategies, and promoting interdisciplinary collaboration on sustainability issues.

References

- Albreiki, B., Habuza, T., Shuqfa, Z., Serhani, M. A., Zaki, N., & Harous, S. (2021). Customized Rule-Based Model to Identify At-Risk Students and Propose Rational Remedial Actions. *Big Data and Cognitive Computing*, 5(4), 71.
- Aldholay, A., Isaac, O., Jalal, A. N., Anor, F. A., & Mutahar, A. M. (2021). Towards a better understanding of the Organizational Characteristics that affect Acceptance of Big Data Platforms for Academic Teaching. *Indonesian Journal of Electrical Engineering and Informatics (IJEI)*, 9(3), 766-773.
- Bae, A., Park, D., Ahn, Y. Y., & Park, J. (2016). The multi-scale network landscape of collaboration. *PLoS one*, 11(3), e0151784.
- Bonsu, N. O., TyreeHageman, J., & Kele, J. (2020). Beyond agenda 2030: Future-oriented mechanisms in localising the sustainable development goals (SDGs). *Sustainability*, 12(23), 9797.
- Cavus, N., Mrwebi, S. E., Ibrahim, I., Modupeola, T., & Reeves, A. Y. (2022). Internet of Things and Its Applications to Smart Campus: A Systematic Literature Review. *International Journal of Interactive Mobile Technologies*, 17(23).
- Charbel, E. A. (2019). The Impact of Strategic Planning on the Reform of Lebanese Public Administration. *Revista de Management Comparat Internațional*, 20(3), 259-278.
- Chu, X., Cao, F., Jiao, L., Wang, J., & Jiao, Y. (2022). Optimal Allocation of Higher Education Resources Based on Data Mining and Cloud Computing. *Wireless Communications and Mobile Computing*, 2022.
- Falola, H. O., Adeniji, A. A., Osibanjo, A. O., Oludayo, O. A., & Salau, O. P. (2018). Data on perception of faculty members on the influence of faculty support initiatives on the efficacy of job responsibilities. *Data in brief*, 19, 1594-1599.
- Fijałkowska, J., & Hadro, D. (2018). Intellectual capital reporting of universities—A third mission oriented approach to communication with stakeholders. *International Journal of Contemporary Management*, 17(4).
- Gan, Y., & Jie, B. (2022). Research on Optimization of Student Management Evaluation System under the Background of Big Data. *Wireless Communications and Mobile Computing*, 2022.
- Griffin, C. R. (2018). Adopting a strategic approach to matching people to jobs. *International Journal of Business and Management*, 13(4), 1-10.
- Hamoud, A.K., Hashim, A.S., & Awadh, W.A. (2018). Predicting Student Performance in Higher Education Institutions Using Decision Tree Analysis. *Int. J. Interact. Multim. Artif. Intell.*, 5, 26-31.
- Jiang, Q. & Zhang, L. (2022). Higher Education Management Analysis of Smart Transportation Big Data Application under the Background of Internet +. *Wireless Communications and Mobile Computing*. 2022. 1-10.
- Krishna, K. P., & Aithal, P. S. (2023). Tech-Business Analytics – a Review-based New Model to Improve the Performances of Various Industry Sectors. *International Journal of Applied Engineering and Management Letters*. 7(1). 67-91.
- Li, W. (2021). Innovation and Development of University Education Management Informationization in the Environment of Wireless Communication and Big Data. *Wireless Communication and Mobile Computing*. 2021.1-6.

- Moscoso-Zea, O., Castro, J., Paredes-Gualtor, J., & Luján-Mora, S. (2019). A hybrid infrastructure of enterprise architecture and business intelligence & analytics for knowledge management in education. *IEEE access*, 7, 38778-38788.
- Munshi, A. A., & Alhindi, A. (2021). Big Data Platform for Educational Analytics. *IEEE Access*, 9, 52883-52890.
- Owan, V. J., & Offu, O. E. (2021). Standardised predictive linear models of managerial processes and the sustainability of graduate programmes (SGPs) in universities: A case study. *Owan, VJ, & Offu, OE (2021). Standardised predictive linear models of managerial processes and the sustainability of graduate programmes (SGPs) in universities: A case study. Contemporary Mathematics and Science Education*, 2(1).
- Parkin, J. (2022). You did what at the weekend? - A workshop to develop the digital awareness and understanding of digital footprints amongst primary education studies undergraduates. *Compass: Journal of Learning and Teaching*, 15(2), 22-31.
- Renanita, T. & Himam, F. (2020). Organizational Change and The Human Resource Challenges in Facing Technology Development. *Digital Press Social Sciences and Humanities*. 5.10.
- Regueras, L. M., et.al. (2019). Clustering Analysis for Automatic Certification of LMS Strategies in a University Virtual Campus. *IEEE Access*, 7, 137680-137690.
- Rossi, R. & Hirama, K. (2022). Analytical Engineering for Data Stream. *Journal of Computer and Communications*. 10. 13-34.
- Saheed, Y. K., Oladele, T. O., Akanni, A. O., & Ibrahim, W. M. (2018). Student performance prediction based on data mining classification techniques. *Nigerian Journal of Technology*, 37(4), 1087-1091.
- Santoso L.W. (2018) Academic Decision Support System for Top Management. *Advances in Natural and Applied Sciences.*, 12(4): 27-32.
- Tarnate, K. J. M., & Devaraj, M. (2019). Prediction of ISO 9001: 2015 audit reports according to its major clauses using recurrent neural networks. *Int. J. Recent Technol. Eng*, 8(2), 1773-1778.
- Wang, J. (2022). Research on the Reform of Higher Education Training Mode under the Background of Big Data and Internet of Things. *Wireless Communications and Mobile Computing*, 2022.
- West, D., Luzecky, A., Toohey, D., Vanderlelie, J., & Searle, B. (2020). Do academics and university administrators really know better? The ethics of positioning student perspectives in learning analytics. *Australasian Journal of Educational Technology*, 36(2), 60-70.
- Yin, S. C. N. (2016). Identification of Early Predictors of Adult Learners' Academic Performance in Higher Education. *IAFOR Journal of Education*, 4(2), 16-32.
- Zhao, H. (2022). Research on the Application of Improved Decision Tree Algorithm based on Information Entropy in the Financial Management of Colleges and Universities. *International Journal of Advanced Computer Science and Applications*, 13(12).
- Zhao, J. (2022). Integrating mental health education into french teaching in university based on artificial intelligence technology. *Journal of Environmental and Public Health*, 2022.