Data-Driven Decision Making in Academic Libraries: A Review of Developments and Future Prospects

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ABSTRACT

Computer data has been used for many years to support data-driven decision-making. The current study focuses on the fundamental principles of data-driven decision-making in education and learning and how it can potentially transform libraries in the future. The study was conducted in five phases using the scoping review. The decision-making process and early developments, role in educational administration, application in libraries, methods and techniques for data-driven decision-making, most recent advancements, and post-COVID-19 developments in decision-making are all included for discussion based on the data.

KEYWORDS: Data-driven decision-making; Decision making in libraries; Data; Decision making and techniques.

INTRODUCTION

Data-driven decision-making has been observed in many areas of the life spectrum. Although accountability, involvement, and computer data systems have been instrumental, various studies (Isaacs, 2003; Wayman, 2005; Marsh, Pane & Hamilton, 2006) from the early past have witnessed smooth development in such areas. Data-driven decision-making has come forward in layers of supporting inquiry and reflections with the help of computer data. While education and learning have witnessed data-driven decision-making support, libraries have come so far in using data-driven decision-making in contemporary times. To project the future of libraries using the data-driven decision-making approach, it is necessary to review and analyze how data-driven decision-making became a tool in managing education and other learning environments.

OBJECTIVES

The present paper focuses on two areas through literature:

- ✓ What are the thrust areas of data-driven decision-making in education and learning environments?
- ✓ How will data-driven decision-making become capable of changing the future of libraries?

METHOD

The present study has applied scoping review method by mapping the literature on a particular topic or research area and providing an opportunity to identify key concepts, gaps in the research, and types and sources of evidence to inform practice and policymaking (i*). The review includes the following five key phases: (1) identifying the research question, (2) identifying relevant studies, (3) study selection, (4) charting the data, and (5) collating, summarizing, and reporting the results.

a. Research question

This review was guided by question such as what are the recent developments in the area of data driven decision making in education, learning and libraries.

b. Data sources and search strategy

The initial search was implemented on 3rd, 4th, and 5th of May 2023 on Google Scholar, selected to be comprehensive and to cover a broad range of subject scope and timeframe. No limits on date, language, subject or type were placed on the search. The search query consisted of terms considered to describe:

I.   Data-driven decision making
II. Data-driven decision-making in education and learning
III. Data-driven decision-making in libraries

The search query was tailored to the specific requirements of the study. Data was arranged in tables for smooth display and further analysis.

c. Citation management

All citations were imported from Google Scholar in APA style format option, and duplicate citations were removed manually when found as retrieval results later in the search process conducted for three days consecutively.

d. Eligibility criteria

A two-stage screening process was used to assess the relevance of studies identified in the search. Studies were eligible for inclusion if they broadly described data-driven decision-making to identify and characterize the existing literature or evidence based on a broad topic. Because of limited resources for translation, articles published in the English language were included.

e. Data characterization

All citations deemed relevant after the title and abstract screening were tabulated for subsequent review of the full-text article. A table/form was developed by the authors to confirm the relevance and to extract study characteristics such as publication year, publication type, study sector, terminology, etc.

(i*) Arksey, H., & O'Malley, L. (2005). Scoping studies: towards a methodological framework. International journal of social research methodology, 8(1), 19-32. DOI: 10.1080/1364557032000119616

DATA SUMMARY AND SYNTHESIS

The following tables present the mapped literature in every research area:

Sl. No.	Data Driven Decision making and early developments
1.	Isaacs, M. L. (2003). Data-driven decision making: The engine of accountability. *Professional School Counseling*, *6*(4), 288-295.
2.	Wayman, J. C. (2005). Involving teachers in data-driven decision making: Using computer data systems to support teacher inquiry and reflection. *Journal of education for students placed at risk*, *10*(3), 295-308.
3.	Marsh, J. A., Pane, J. F., & Hamilton, L. S. (2006). Making sense of data-driven decision making in education: Evidence from recent RAND research. Occasional Paper. *Rand Corporation*.
4	Mandinach, E. B., Honey, M., & Light, D. (2006, April). A theoretical framework for data-driven decision making. In *Annual Meeting of the American Educational Research Association, San Francisco, CA*.
5.	James, E. A., Milenkiewicz, M. T., & Bucknam, A. (2007). *Participatory action research for educational leadership: Using data-driven decision making to improve schools*. Sage Publications.
6.	Hedgebeth, D. (2007). Data-driven decision making for the enterprise: An overview of business intelligence applications. *Vine*, *37*(4), 414-420.

Table: 1

Sl. No.	Decision Making and Techniques: Applications and Time Significance	Sl. No.	Decision making and techniques: Assessment and deliverance
1.	Wohlstetter, P., Datnow, A., & Park, V. (2008). Creating a system for data-driven decision-making: Applying the principal-agent framework. *School effectiveness and school improvement*, *19*(3), 239-259.	1.	Mandinach, E. B., & Jackson, S. S. (2012). *Transforming teaching and learning through data-driven decision making*. Corwin Press.
2.	Brynjolfsson, E., Hitt, L. M., & Kim, H. H. (2011). Strength in numbers: How does data-driven decision making affect firm performance?. *Available at SSRN 1819486*.	2.	Dunn, K. E., Airola, D. T., Lo, W. J., & Garrison, M. (2013). Becoming data driven: The influence of teachers' sense of efficacy on concerns related to data-driven decision making. *The Journal of Experimental Education*, *81*(2), 222-241.
3.	Mandinach, E. B. (2012). A perfect time for data use: Using data-driven decision making to inform practice. *Educational Psychologist*, *47*(2), 71-85.	3.	Kaufman, T. E., Graham, C. R., Picciano, A. G., Popham, J. A., & Wiley, D. (2014). Data-driven decision making in the K-12 classroom. *Handbook of research on educational communications and technology*, 337-346.

Table: 2

Sl. No.	Educational administration and decision making		Extended learning and research
1.	Marsh, J. A., & Farrell, C. C. (2015). How leaders can support teachers with data-driven decision making: A framework for understanding capacity building. *Educational Management Administration & Leadership*, *43*(2), 269-289.	1.	Datnow, A., & Hubbard, L. (2016). Teacher capacity for and beliefs about data-driven decision making: A literature review of international research. *Journal of Educational Change*, *17*, 7-28.
2.	Brynjolfsson, E., & McElheran, K. (2016). The rapid adoption of data-driven decision-making. *American Economic Review*, *106*(5), 133-139.	2.	Blummer, B., & Kenton, J. M. (2018). Big data and libraries: identifying themes in the literature. *Internet Reference Services Quarterly*, *23*(1-2), 15-40.
3.	Ballou, B., Heitger, D. L., & Stoel, D. (2018). Data-driven decision-making and its impact on accounting undergraduate curriculum. *Journal of Accounting Education*, *44*, 14-24.	3.	Ballou, B., Heitger, D. L., & Stoel, D. (2018). Data-driven decision-making and its impact on accounting undergraduate curriculum. *Journal of Accounting Education*, *44*, 14-24.
		4.	Koltay, T. (2019). Accepted and emerging roles of academic libraries in supporting research 2.0. *The Journal of Academic Librarianship*, *45*(2), 75-80.

Table: 3

Sl. No.	Libraries and Data driven decision making		*Library spectrum, data and decision making*
1.	Hernon, P., & McClure, C. R. (1990). *Evaluation and library decision making* (p. xv).	1.	Spalding, H. H., & Wang, J. (2006). The challenges and opportunities of marketing academic libraries in the USA: Experiences of US academic libraries with global application. *Library management*.
2.	Norwood, NJ: Ablex. Veldof, J. R. (1999). Data driven decisions: using data to inform process changes in libraries. *Library & information science research*, *21*(1), 31-46.	2.	Decker, R., & Höppner, M. (2006). Strategic planning and customer intelligence in academic libraries. *Library Hi Tech*, *24*(4), 504-514.
3.	Dole, W. V., Liebst, A., & Hurych, J. M. (2006). Using performance measurement for decision making in mid-sized academic libraries. *Performance Measurement and Metrics*.	3.	Lakos, A. (2007). Evidence-based library management: The leadership challenge. *portal: Libraries and the Academy*, *7*(4), 431-450.
		4.	Provost, F., & Fawcett, T. (2013). Data science and its relationship to big data and data-driven decision making. *Big data*, *1*(1), 51-59.

Table: 4

Sl. No.	Methods and techniques for Data driven Decision		Recent advances and data techniques
1.	Nazemi, K., Retz, R., Burkhardt, D., Kuijper, A., Kohlhammer, J., & Fellner, D. W. (2015, October). Visual trend analysis with digital libraries. In *Proceedings of the 15th International Conference on Knowledge Technologies and Data-driven Business* (pp. 1-8).	1.	Bernard, J., Daberkow, D., Fellner, D., Fischer, K., Koepler, O., Kohlhammer, J., ... & Sens, I. (2015). Visinfo: a digital library system for time series research data based on exploratory search—a user-centered design approach. *International Journal on Digital Libraries*, *16*, 37-59.
2.	De Mauro, A., Greco, M., & Grimaldi, M. (2016). A formal definition of Big Data based on its essential features. *Library review*, *65*(3), 122-135.	2.	Li, S., Jiao, F., Zhang, Y., & Xu, X. (2019). Problems and changes in digital libraries in the age of big data from the perspective of user services. *The Journal of Academic Librarianship*, *45*(1), 22-30.
3.	Kamupunga, W., & Chunting, Y. (2019). Application of big data in libraries. *International Journal of Computer Applications*, *178*(16), 34-38.	3.	Tzanova, S. (2020). Changes in academic libraries in the era of Open Science. *Education for Information*, *36*(3), 281-299.
		4.	Travis, T. A., & Ramirez, C. (2020). Big data and academic libraries: the quest for informed Decision-Making. *portal: Libraries and the Academy*, *20*(1), 33-47.

Table: 5

Sl. No.	Post covid-19 developments and Data driven decision making in libraries
1.	Kurilovas, E. (2020). On data-driven decision-making for quality education. *Computers in Human Behavior*, *107*, 105774.
2.	Yu, S., Qing, Q., Zhang, C., Shehzad, A., Oatley, G., & Xia, F. (2021). Data-driven decision-making in COVID-19 response: A survey. *IEEE Transactions on Computational Social Systems*, *8*(4), 1016-1029.
3.	Wu, C., Wu, P., Wang, J., Jiang, R., Chen, M., & Wang, X. (2021). Critical review of data-driven decision-making in bridge operation and maintenance. *Structure and Infrastructure Engineering*, *18*(1), 47-70.
4.	Bousdekis, A., Lepenioti, K., Apostolou, D., & Mentzas, G. (2021). A review of data-driven decision-making methods for industry 4.0 maintenance applications. *Electronics*, *10*(7), 828.
5.	Tella, A. (2021). Librarians' perception of opportunities and challenges associated with big data in public libraries. *Internet Reference Services Quarterly*, *24*(3-4), 89-113.
6.	Fitzgerald, S. R., Hutton, S., Reznik-Zellen, R., Barlow, C., & Oldham, W. (2023). Decision-Making by and for Academic Libraries during COVID-19. *portal: Libraries and the Academy*, *23*(1), 45-65.

| 7. | Gupta, V., & Rubalcaba, L. (2022). University libraries as open innovation partners: Harnessing hidden potential to foster global entrepreneurship. *The Journal of Academic Librarianship*, *48*(2), 102432. |
| 8. | Sanap, G. R. (2023). Big Data and Libraries. *International Interdisciplinary Research Journal (AIIRJ)*. |

Table: 6

Comprehensive view of searches and results

Sl. No.	Concepts and search strings	No.	% (approx. in round figures)
1.	Data Driven Decision making and early developments	6	15
2.	Decision making and techniques ; Applications and Time significance	3	7
3.	Decision making and techniques ; Assessment and deliverance	3	7
4.	Educational administration and decision making	3	7
5.	Extended learning and research	4	10
6.	Libraries and Data driven decision making	3	7
7.	*Library spectrum, data and decision making*	4	10
8.	Methods and techniques for Data driven Decision	3	7
9.	Recent advances and data techniques	4	10
10.	Post covid-19 developments and Data driven decision making in libraries	8	20
	Total	41	

Table: 7

DISCUSSION

Decision-making and early developments

Where the computer-based data can be given a pivotal role of decision-making, the frameworks have been designed to help this proliferation. Actions and steps such as educational aspects, participatory action research, and enterprising approaches played a definitive role in establishing data-driven decision-making in the learning sector. During the midyears of the millennium initiation, there have been attempts to create frameworks, educational leadership (Mandinach & Light, 2006; James, Milenkiewicz & Bucknam, 2007), and intelligent applications (Hedgebeth, 2007) for the awareness and applications of data-driven decision making in education and learning sector.

Decision-making refers to using computer-based data and information to make choices and take proof-based actions. Where computer-based data can be pivotal in decision-making, frameworks have been designed to help this proliferation. Actions and steps such as educational aspects, participatory action research, and enterprising approaches played a definitive role in establishing data-driven decision-making in the learning sector. To facilitate the integration of computer-based data into decision-making in the learning sector, attempts to develop frameworks on educational leadership (Mandinach & Light, 2006; James, Milenkiewicz & Bucknam, 2007) and intelligent applications (Hedgebeth, 2007) were made. These frameworks serve as guidelines or structures for incorporating data analysis and interpretation into decision-making processes. They provide a systematic and organized way to leverage the potential of data for improving educational outcomes.

A critical aspect of promoting data-driven decision-making is focusing on education and awareness. Efforts have been made to raise awareness among educators and administrators about the benefits and significance of using data for decision-making. This includes providing educational resources, training programs, and workshops to enhance their understanding of data analysis and its application in educational settings. Another approach that has been utilized is participatory action research. This method involves collaboration between researchers, educators, and other stakeholders to collect and analyze data, identify problems or challenges, and develop strategies for improvement. Participatory action research promotes a more inclusive and holistic approach to data-driven decision-making by involving various stakeholders in the decision-making process.

Additionally, enterprising approaches have fostered a culture of data-driven decision-making in the learning sector. This involves encouraging innovative and entrepreneurial thinking in utilizing data to identify opportunities, solve problems, and make informed choices. By nurturing a mindset of exploration and experimentation, enterprising approaches support the effective integration of data into decision-making.

During the midyears of the millennium, efforts were made to establish frameworks for data-driven decision-making in education. These included frameworks for educational leadership, which emphasized the role of leaders in utilizing data to inform decision-making and drive improvements in educational practices. Furthermore, intelligent applications, such as data analytics tools and software, were developed to assist in analyzing and interpreting data in the education sector.

Overall, these initiatives and developments aimed to promote the effective use of computer-based data for decision-making in the learning sector, aiming to improve educational outcomes and foster evidence-based practices.

Decision-making and techniques

The last decade observed various significant steps progressing towards data-driven decision-making for increasing performance. The creation of such a system, where data can play a pivotal role in decision-making, requires the application of data-driven techniques. For example, applying the principal-agent framework (Wohlstetter, Datnow & Park, 2008; Brynjolfsson, Hitt & Kim, 2011) could be helpful to while it is also essential to assess the impact of data-driven decision-making (Mandinach, 2012) for developing a system for data-driven decision-making.

In the past decade, there have been notable advancements in the realm of data-driven decision-making aimed at improving performance. Various data-driven techniques have been applied to establish a system where data plays a crucial role in decision-making. One such technique is the principal-agent framework. This framework, as highlighted by Wohlstetter, Datnow, and Park (2008) and Brynjolfsson, Hitt, and Kim (2011), can be helpful in data-driven decision-making. The principal-agent framework examines the relationship between the principal (the decision maker) and the agent (the individual or system responsible for executing the decisions). By applying this framework, decision-makers can better understand how to align incentives, set goals, and monitor agents' performance in utilizing data for decision-making. It helps ensure that the decision-making process is optimized and data is effectively used to achieve desired outcomes.

Assessing the impact of data-driven decision-making is another crucial aspect of developing a system for effective data-driven decision-making. Mandinach (2012) emphasizes the importance of evaluating the outcomes and effects of using data in decision-making processes. By conducting systematic assessments, decision-makers can understand the strengths and weaknesses of data-driven approaches, identify areas for improvement, and make informed adjustments to their decision-making strategies. This evaluation process helps refine the system and enhances its effectiveness over time.

As a whole, the past decade has witnessed significant progress in data-driven decision-making techniques. By applying frameworks like the principal-agent model and continuously assessing the impact of data-driven decision-making, organizations, and decision-makers can develop robust systems that leverage data effectively to drive performance and achieve desired outcomes.

Applications and Time Significance

There must have been many examples and experiences from the industry to understand the significance of time and data application. Decision-making depends on constituent components such as data, computer applications, timely inclusion, and practice. Timeliness and quality of data are crucial in the transformation (Mandinach, 2012) of the learning sector.

Assessment and deliverance

Educators' sense of quality teaching, concerns and communications are essential in the learning and education sectors. The trainers and learners have assessed the role of data and data-driven decision-making in the context of the influence of teachers and K-12 classrooms (Mandinach & Jackson, 2012; Dunn, Airola, Lo & Garrison, 2013; Kaufman, Graham, Picciano, Popham & Wiley, 2014) in the beginning of last decade.

Educational administration and decision making

Roles of educational leaders have found the support mechanisms for educators. Data-driven decision-making has benefited from frameworks for capacity building. Educational management and administrative leadership (Marsh & Farrell, 2015; Brynjolfsson & McElheran, 2016) can evolve with the active inclusion of data-driven decision-making. The proliferation and augmented adoption of data-driven decision-making (Brynjolfsson & McElheran, 2016; Ballou, Heitger & Stoel, 2018) plays an instrumental role.

Extended learning and research

How data-driven decision-making is perceived among professionals and educators is another significant aspect of understanding the impact of data-driven tactics. The advent of big data roles in the learning and information sector has also paved the way for data-driven decision-making in reference services as well as curriculum (Datnow & Hubbard, 2016; Blummer & Kenton, 2018; Ballou, Heitger & Stoel, 2018). Involvement of data-driven decision-making in various aspects such as eductaoinal services, information scenario creation, and emerging roles of academic libraries has been visualized. Research support has become another central area (Ballou, Heitger & Stoel, 2018; Koltay, 2019) for the use and application of data-driven decision-making.

Libraries and Data-driven decision making

Since the era of ending last millennium, the applications of decision-making process in libraries have embarked. The advent of technology and computers becoming ubiquitous have provided new genera in decision-making steps. Whereas there have been attempts to assess the library decision-making processes, the inclusion of data-driven efforts created paths for using data to induce changes in libraries. Significant studies have provided such glimpses (Hernon & McClure, 1990; Veldof, 1999; Dole, Liebst & Hurych, 2006) with the beginning of the new millennium with more experiences. Once libraries were opting for new responsibilities and personifying multiple roles, the demands of data in various aspects increased inside libraries. There have been opportunities and challenges for understanding the exponential growth of data and using the same for decision-making in libraries. Multiple areas of application of data-driven decision-making may include marketing of academic libraries, performance measurement, process changes, and assessment of situations.

Library spectrum, data, and decision making

The past has witnessed experiences of few challenges in diverse roles and functions of libraries leading to new learnings, enhanced planning, and far-sighted visions. The global scenario observed during the last two decades is buying technologies to explore data-driven decision-making in the sharpest ways. Academic libraries often indulge in marketing information resources and services; understanding library customers, and leadership issues (Spalding & Wang, 2006; Decker & Höppner, 2006; Lakos, 2007; Provost & Fawcett, 2013). Such areas often rely on meticulously collected user data to redesign services and collection building in specific subject areas.

Methods and Techniques for Data-driven Decision

Evidence-based library management has emerged as a reliable technique wherever there have been leadership challenges. The emergence of data science and various peripherals, such as big data, have compelled libraries to opt for data-driven decision-making. The application of visual trend analysis and big data has become a practice for almost a decade. From the deep understanding of big data applications in conventional as well as digital libraries, moving towards applications of knowledge technologies (Nazemi, Retz, Burkhardt, Kuijper, Kohlhammer & Fellner, 2015; De Mauro, Greco & Grimaldi, 2016; Kamupunga & Chunting, 2019) are based on computer applications.

Recent advances and data techniques

Digital library systems have charmed the data-driven decision-making in multiple aspects. Examples reflect the application of time series research data, big data into digital libraries, and opportunities for open science. User-centric design approaches are instrumental in the augmented usage of digital library platforms in academic scenarios. Big data applications have paved the way for opportunities as well as challenges. In a study, the example of Visinfo (Bernard, Daberkow, Fellner, Fischer, Koepler, Kohlhammer, ... & Sens, 2015) has shown library developments. User services have been identified as the most significant areas in academic libraries. Application of big data, open science, and decision-making have been interrelated (Li, Jiao, Zhang & Xu, 2019; Tzanova, 2020; Travis & Ramirez, 2020) in a few studies.

Post covid-19 developments and Decision making

Post covid-19, there have been tremendous changes and needs to understand for quick strategizing learning and information scenario. Quality education and responding to learning needs while providing information services to users are significant factors for applying data-driven decision-making in the learning environment. Literature has shown some trends and examples where data-driven decision-making has been influential for learning transactions and maintenance (Kurilovas, 2020; Yu, Qing, Zhang, Shehzad, Oatley & Xia, 2021; Wu, Wu, Wang, Jiang, Chen & Wang, 2021; Bousdekis, Lepenioti, Apostolou & Mentzas, 2021) of information services.

Academic institutions and the corresponding libraries are applying data-driven techniques to quest for better decisions and provisions of user-oriented information services. Such examples include internet-based reference services, conditions of Covid-19 portals, and quick information services (Tella, 2021; Fitzgerald, Hutton, Reznik-Zellen, Barlow & Oldham, 2023). Covid-19 also brought a few vistas for enhanced learning and challenges for new thinking and planning.

During the last two years, libraries have become experimental at a great level to include technologies and induce a changed environment. Harnessing the hidden potential and using data for a fast decision-making process has made smart libraries open for innovative partnerships (Gupta & Rubalcaba, 2022; Sanap, 2023). Discerning the interdisciplinary needs of users' communities and relishing competitive edge has compelled academic libraries to opt for data-driven decision-making in their endeavors, such as resource planning and service designing.

CONCLUSION

Data-driven decision-making has many uses that can improve performance, including developing marketing strategies, managing change, performance management, making changes to processes, and situation assessment. Additionally, it has paved the way for the process improvement of curriculum and reference services among professionals and educators. The design of services and the planning of resources have become increasingly dependent on data-driven decisions. Additionally, it fosters leadership development in the area of educational administration. However, academic libraries, particularly during COVID-19, have reacted favorably to data-driven decision-making for user-oriented information services such as internet-based quick information services. With the development of ICT, there has been a dramatic exponential growth in the case of libraries, including the decision-making for resource procurement and service marketing.

REFERENCES

[1] Isaacs, M. L. (2003). Data-driven decision making: The engine of accountability. *Professional School Counseling*, *6*(4), 288-295.

[2] Wayman, J. C. (2005). Involving teachers in data-driven decision making: Using computer data systems to support teacher inquiry and reflection. *Journal of education for students placed at risk*, *10*(3), 295-308.

[3] Marsh, J. A., Pane, J. F., & Hamilton, L. S. (2006). Making Sense of Data-Driven Decision Making in Education: Evidence from Recent RAND Research. Occasional Paper. *Rand Corporation*.

[4] Mandinach, E. B., Honey, M., & Light, D. (2006, April). A theoretical framework for data-driven decision making. In *annual meeting of the American Educational Research Association, San Francisco, CA*.

[5] James, E. A., Milenkiewicz, M. T., & Bucknam, A. (2007). *Participatory action research for educational leadership: Using data-driven decision making to improve schools*. Sage Publications.

[6] Hedgebeth, D. (2007). Data-driven decision making for the enterprise: an overview of business intelligence applications. *Vine*, *37*(4), 414-420.

[7] Wohlstetter, P., Datnow, A., & Park, V. (2008). Creating a system for data-driven decision-making: Applying the principal-agent framework. *School effectiveness and school improvement*, *19*(3), 239-259.

[8] Brynjolfsson, E., Hitt, L. M., & Kim, H. H. (2011). Strength in numbers: How does data-driven decision-making affect firm performance?. *Available at SSRN 1819486*.

[9] Mandinach, E. B. (2012). A perfect time for data use: Using data-driven decision making to inform practice. *Educational Psychologist*, *47*(2), 71-85.

[10] Mandinach, E. B., & Jackson, S. S. (2012). *Transforming teaching and learning through data-driven decision making*. Corwin Press.

[11] Dunn, K. E., Airola, D. T., Lo, W. J., & Garrison, M. (2013). Becoming data driven: The influence of teachers' sense of efficacy on concerns related to data-driven decision making. *The Journal of Experimental Education*, *81*(2), 222-241.

[12] Kaufman, T. E., Graham, C. R., Picciano, A. G., Popham, J. A., & Wiley, D. (2014). Data-driven decision making in the K-12 classroom. *Handbook of research on educational communications and technology*, 337-346.

[13] Marsh, J. A., & Farrell, C. C. (2015). How leaders can support teachers with data-driven decision making: A framework for understanding capacity building. *Educational Management Administration & Leadership*, *43*(2), 269-289.

[14] Brynjolfsson, E., & McElheran, K. (2016). The rapid adoption of data-driven decision-making. *American Economic Review*, *106*(5), 133-139.

[15] Datnow, A., & Hubbard, L. (2016). Teacher capacity for and beliefs about data-driven decision making: A literature review of international research. *Journal of Educational Change*, *17*, 7-28.

[16] Blummer, B., & Kenton, J. M. (2018). Big data and libraries: identifying themes in the literature. *Internet Reference Services Quarterly*, *23*(1-2), 15-40.

[17] Ballou, B., Heitger, D. L., & Stoel, D. (2018). Data-driven decision-making and its impact on accounting undergraduate curriculum. *Journal of Accounting Education*, *44*, 14-24.

[18] Koltay, T. (2019). Accepted and emerging roles of academic libraries in supporting research 2.0. *The Journal of Academic Librarianship*, *45*(2), 75-80.

[19] Kurilovas, E. (2020). On data-driven decision-making for quality education. *Computers in Human Behavior*, *107*, 105774.

[20] Yu, S., Qing, Q., Zhang, C., Shehzad, A., Oatley, G., & Xia, F. (2021). Data-driven decision-making in COVID-19 response: A survey. *IEEE Transactions on Computational Social Systems*, *8*(4), 1016-1029.

[21] Wu, C., Wu, P., Wang, J., Jiang, R., Chen, M., & Wang, X. (2021). Critical review of data-driven decision-making in bridge operation and maintenance. *Structure and Infrastructure Engineering*, *18*(1), 47-70.

[22] Bousdekis, A., Lepenioti, K., Apostolou, D., & Mentzas, G. (2021). A review of data-driven decision-making methods for industry 4.0 maintenance applications. *Electronics*, *10*(7), 828.

[23] Hernon, P., & McClure, C. R. (1990). *Evaluation and library decision making* (p. xv). Norwood, NJ: Ablex.

[24] Veldof, J. R. (1999). Data driven decisions: using data to inform process changes in libraries. *Library & information science research*, *21*(1), 31-46.

[25] Dole, W. V., Liebst, A., & Hurych, J. M. (2006). Using performance measurement for decision making in mid-sized academic libraries. *Performance Measurement and Metrics*.

[26] Spalding, H. H., & Wang, J. (2006). The challenges and opportunities of marketing academic libraries in the USA: Experiences of US academic libraries with global application. *Library management*.

[27] Decker, R., & Höppner, M. (2006). Strategic planning and customer intelligence in academic libraries. *Library Hi Tech*, *24*(4), 504-514.

[28] Lakos, A. (2007). Evidence-based library management: The leadership challenge. *portal: Libraries and the Academy*, *7*(4), 431-450.

[29] Provost, F., & Fawcett, T. (2013). Data science and its relationship to big data and data-driven decision making. *Big data*, *1*(1), 51-59.

[30] Nazemi, K., Retz, R., Burkhardt, D., Kuijper, A., Kohlhammer, J., & Fellner, D. W. (2015, October). Visual trend analysis with digital libraries. In *Proceedings of the 15th International Conference on Knowledge Technologies and Data-driven Business* (pp. 1-8).

[31] De Mauro, A., Greco, M., & Grimaldi, M. (2016). A formal definition of Big Data based on its essential features. *Library review*, *65*(3), 122-135.

[32] Kamupunga, W., & Chunting, Y. (2019). Application of big data in libraries. *International Journal of Computer Applications*, *178*(16), 34-38.

[33] Bernard, J., Daberkow, D., Fellner, D., Fischer, K., Koepler, O., Kohlhammer, J., ... & Sens, I. (2015). Visinfo: a digital library system for time series research data based on exploratory search—a user-centered design approach. *International Journal on Digital Libraries*, *16*, 37-59.

[34] Li, S., Jiao, F., Zhang, Y., & Xu, X. (2019). Problems and changes in digital libraries in the age of big data from the perspective of user services. *The Journal of Academic Librarianship*, *45*(1), 22-30.

[35] Tzanova, S. (2020). Changes in academic libraries in the era of Open Science. *Education for Information*, *36*(3), 281-299.

[36] Travis, T. A., & Ramirez, C. (2020). Big data and academic libraries: the quest for informed Decision-Making. *portal: Libraries and the Academy*, *20*(1), 33-47.

[37] Tella, A. (2021). Librarians' perception of opportunities and challenges associated with big data in public libraries. *Internet Reference Services Quarterly*, *24*(3-4), 89-113.

[38] Fitzgerald, S. R., Hutton, S., Reznik-Zellen, R., Barlow, C., & Oldham, W. (2023). Decision-Making by and for Academic Libraries during COVID-19. *portal: Libraries and the Academy*, *23*(1), 45-65.

[39] Gupta, V., & Rubalcaba, L. (2022). University libraries as open innovation partners: Harnessing hidden potential to foster global entrepreneurship. *The Journal of Academic Librarianship*, *48*(2), 102432.

[40] Sanap, G. R. (2023). Big Data and Libraries. *International Interdisciplinary Research Journal (AIIRJ)*.

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