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Assessing Technology and Digital Platforms for Data-Driven Mathematics teaching and learning in South African Schools

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ABSTRACT
As the world has become more digitalized, technology and digital platforms have revolutionized the way mathematics is taught and learned. It is, however, possible to further transform the way mathematics teaching and learning is conducted by using technology and digital platforms. Schools need to use digital platforms for teaching and learning mathematics to improve performance mathematics since the subject is considered difficult. Data-driven mathematics teaching and learning using technology and digital platforms have been discussed in this article. According to the authors, improved mathematics performance can be achieved by implementing strategies addressing digital platforms, data-driven pedagogy, teacher professional development and student engagement. As a means of achieving meaningful mathematics teaching and learning in South African schools, the authors believe technology and digital platforms can play a significant role. In this theoretical paper, the authors examined a constructivist approach to learning, which holds that learning involves interaction with the environment to construct knowledge. Also incorporated into the framework is the Technology Acceptance Model (TAM), which emphasizes that perceived efficacy, user-friendliness, and social influences impact the adoption and use of technology. As a result of the technology acceptance model, South African schools will be able to overcome challenges like infrastructure limitations and inadequate teacher training to advance the digitalization of information in mathematics education.

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INTRODUCTION
Recent years have seen a surge in the use of technology and digital platforms in education, which has enabled the transformation of traditional classrooms into digital, interactive learning environments. The advent of digital platforms has enabled the collection, storage, and analysis of large amounts of data. This allows educators to make informed teaching and learning decisions. In this paper, the authors explore how technology and digital platforms can be leveraged to promote data-driven mathematics teaching in South African schools. Adam, argues that the use of digital platforms can personalize education, improve student engagement and foster active learning.[1] The emergence of digital technology and data-driven learning has made education systems essential around the world.[2] Data-driven mathematics teaching and learning is based on the collection, analysis,

[1] T Adam, "The Privilege Of# Pivotonline: A South African Perspective," *Open Development & Education* 10 (2020), https://opendeved.net/2020/04/22/the-privilege-of-pivotonline.
[2] Aras Bozkurt and Ramesh C Sharma, "Emergency Remote Teaching in a Time of Global Crisis Due to CoronaVirus Pandemic," *Asian Journal of Distance Education* 15, no. 1 (2020): i–vi.

interpretation and utilization of data to improve mathematics teaching and learning results.[3] In this paper, a comparative analysis of the use of technology and digital platforms for data-driven mathematics teaching and learning in South African schools, the theoretical framework underpinning data-driven teaching and learning and the evaluation of the effectiveness of these tools are perused.

The landscape of mathematics education is undergoing a significant transformation with the integration of technology and digital platforms. This paradigm shift allows teachers to customize mathematics instruction according to the unique needs of each student.[4] While South Africa is making efforts to ensure equal access to education, challenges persist particularly in providing quality mathematics education in underserved communities.[5] According to Davis, and IT Web, the Department of Education (DBE) faces a crisis due to the shortage of qualified teachers and resources.[6] This is adversely affecting the overall quality of mathematics education nationwide. However, technology offers a promising solution to these challenges. Botha, in agreement with Tamborg, avowed that through leveraging digital platforms and data, mathematics performance can be enhanced, educational access can be made easier, and teachers can be empowered with essential skills.[7] However, Jantjies highlights unequal access to education, a lack of qualified teachers, and inadequate infrastructure as the various challenges faced by the South African education system.[8] In response, the government has adopted policies and strategies that incorporate technology in education.[9] The integration of technology can potentially revolutionize mathematics teaching and learning by enabling personalized instruction, progress monitoring, and timely feedback. Digital platforms play a vital role in providing students with access to a wide range of educational resources and facilitating collaboration among peers and teachers.[10]

The focus of this paper is to explore the potential of digital platforms in the education system, examining how they can improve student learning outcomes, enhance teacher effectiveness and contribute to overall improvements in mathematics teaching and learning results. With technology at the helm, South African schools can pave the way for a more equitable and effective mathematics education experience for all students.

LITERATURE REVIEW

Numerous research studies have explored the potential of technology and digital platforms for data-driven learning and teaching.[11] For instance, Kozma's study in 2011 investigated the transformative impact of technology on education, recognizing its game-changing potential. Means et al.'s research in 2010 focused on the positive effects of technology-based learning, showing improvements in student performance.[12] The Technology Acceptance Model (TAM) underpins the theory behind these findings, suggesting that the usefulness and ease of using technology influence its adoption and utilization. The extensive literature on digital technology and data-driven education has demonstrated that utilizing digital platforms can boost student

[3] A. Downton, R. Cross, and J. Auton, "The Outcome of a Flipped Classroom Approach on Student Learning Experience," *Higher Education Journal of Learning and Teaching* 1, no. 1 (2019): 30–41, https://doi.org/https://doi.org/10.32654/hejolt.1.1.30.

[4] Adèle Botha and Marlien Herselman, "A Teacher Tablet Toolkit to Meet the Challenges Posed by 21st Century Rural Teaching and Learning Environments," *South African Journal of Education* 35, no. 4 (2015): 1–19; Kadriye O Lewis et al., "Leveraging E-Learning in Medical Education," *Current Problems in Pediatric and Adolescent Health Care* 44, no. 6 (2014): 150–63.

[5] Zaahedah Vally, "Education Inequality: The Dark Side of South Africa's Education System," The Daily Vox, 2020; South Africa Department of Education [DoE], *White Paper 7 on E-Education* (Cape Town : Government Printers, 2004); Nozuko Nqabeni and Andrea Mqondiso Buka, "Post Covid-19: Exploring the Decolonisation Factor in a Mathematics Classroom in South African Schools," *E-Journal of Humanities, Arts and Social Sciences* 4, no. 3 (March 17, 2023): 287–99, https://doi.org/10.38159/ehass.2023439.

[6] Nicholas Davis, "What Is the Fourth Industrial Revolution," in *World Economic Forum*, vol. 19 (Geneva, Switzerland, 2016), https://www.weforum.org/agenda/2016/01/what-is-thefourth-industrial-revolution/; IT Web, "The Government Makes Provision for Learning during Lockdown," IT Web, 2020, https://www.itweb.co.za/ content/Gb3BwMW8LQKq2k6V.

[7] Botha and Herselman, "A Teacher Tablet Toolkit to Meet the Challenges Posed by 21st Century Rural Teaching and Learning Environments"; Andreas Lindenskov Tamborg, "Improving Mathematics Teaching via Digital Platforms? Implementation Processes Seen through the Lens of Instrumental Genesis," *ZDM – Mathematics Education* 53, no. 5 (October 16, 2021): 1059–71, https://doi.org/10.1007/s11858-021-01282-x.

[8] Mmaki Jantjies, "Five Things South Africa Must Get Right for Technology in Schools to Work," The Conversation, 2019, https://theconversation.com/five-things-South-Africa-must-get-right-for-tech-in-schools-to-work-118612.

[9] Department of Education [DoE], *White Paper 7 on E-Education*.

[10] IT Web, "The Government Makes Provision for Learning during Lockdown"; S H Hasan Khan, "Constructivism: Towards a Paradigm Shift in Classroom Teaching & Learning," *Scholarly Research Journal for Interdisciplinary Studies* 6, no. 51 (2019): 55–63.

[11] Chaomei Chen, "A Glimpse of the First Eight Months of the COVID-19 Literature on Microsoft Academic Graph: Themes, Citation Contexts, and Uncertainties," *Frontiers in Research Metrics and Analytics* 5 (December 23, 2020), https://doi.org/10.3389/frma.2020.607286; Nicky Roberts et al., "From Challenging Assumptions to Measuring Effect: Researching the Nokia Mobile Mathematics Service in South Africa," *South African Journal of Education* 35, no. 2 (May 31, 2015): 1–13, https://doi.org/10.15700/saje.v35n2a1045; Robert B Kozma and Shafika Isaacs, *Transforming Education: The Power of ICT Policies* (Unesco, 2011), https://unesdoc.unesco.org/ark:/48223/pf0000211842.

[12] Barbara Means et al., "Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies," 2009, http://lst-iiep.iiep-unesco.org/cgi-bin/wwwi32.exe/[in=epidoc1.in]/?t2000=027003/(100).

engagement, motivation, and academic achievements.[13] With the help of learning management systems and other digital platforms, educators may monitor student performance, give individualized feedback, and improve learning outcomes. Data analytics can help teachers find areas where pupils struggle so that other teaching strategies can be used. Specifically, the sociocultural theory of learning is the subject of this paper. The active, social element of learning is emphasized, and the sociocultural circumstances have an impact on how learning experiences are formed. Additionally, learning analytics, which involves using data to guide educational decisions, has proven effective in boosting student engagement, academic achievement, and individualized learning experiences.[14]

Liu and Chen, affirm that data-driven learning involves using data to inform teaching and learning decisions and improve student outcomes.[15] Various methods such as assessments, surveys and observations, can be used to collect data. This approach helps identify students' strengths and weaknesses and guides instructional planning, enabling better student achievement and teacher effectiveness. The use of technology and digital platforms is increasingly prevalent in education worldwide.[16] One such platform is the Learning Management System (LMS), where instructors can deliver course materials, interact with students, track their progress, and more.[17] LMSs facilitate student engagement, collaboration and feedback from teachers. Technology and digital platforms play a crucial role in enabling data-driven education by providing up-to-date information on student performance. This data can be used to recognize strengths and weaknesses, monitor progress, and inform instructional decisions.[18]

The Role of Technology in Transforming Mathematics Education

The impact of technology on mathematics education has been substantial and continues to evolve with the emergence of new digital platforms and technologies. By embracing personalized learning, educators can now customize learning experiences to match individual students' needs, interests, and learning styles.[19] Digital platforms facilitate the collection and analysis of data on student performance, preferences and progress. This enables teachers to identify the strengths and weaknesses of learners more effectively. With this valuable data, instructors can tailor their teaching methods and offer targeted support, ultimately helping each student reach their full potential. Real-time assessment capabilities provided by digital platforms further enhance teaching by allowing teachers to gauge student understanding and progress immediately.[20] This replaces the traditional approach of waiting for end-of-term exams, as formative assessment tools now enable continuous monitoring and adjustments to instruction based on student performance.

Coeckelbergh emphasizes that technology opens up access to interactive learning tools and simulations, making abstract mathematical concepts more tangible and engaging.[21] Visual and interactive exploration of mathematical ideas fosters a deeper understanding of complex topics among students. According to Ke, Xie & Xie, virtual manipulatives, graphing calculators, and educational games are examples of such tools that enhance the learning experience.[22] Santos highlights that technology empowers educators with data analytics tools to make informed decisions about curriculum design, instructional strategies and resource allocation.[23] By analyzing data from student assessments and learning analytics, educators can identify trends, adapt their teaching methods and develop evidence-based interventions for struggling students. Moreover, digital platforms

[13] Tamborg, "Improving Mathematics Teaching via Digital Platforms?..."; Chen, "A Glimpse of the First Eight Months of the COVID-19 Literature on Microsoft Academic Graph…"; B. Kanmani and K. Mallikharjuna Babu, "Leveraging Technology in Outcome-Based Education," in *Proceedings of the International Conference on Transformations in Engineering Education: ICTIEE 2014* (Springer, 2015), 415–21.

[14] Yang Liu and Senlin Chen, "Physical Literacy in Children and Adolescents: Definitions, Assessments, and Interventions," *European Physical Education Review* 27, no. 1 (February 11, 2021): 96–112, https://doi.org/10.1177/1356336X20925502.

[15] Liu and Chen, "Physical Literacy in Children and Adolescents: Definitions, Assessments, and Interventions."

[16] Joseline M. Santos, "Google Classroom: Beyond the Traditional Setting," *Problems of Education in the 21st Century* 79, no. 4 (August 15, 2021): 626–39, https://doi.org/10.33225/pec/21.79.626.

[17] Roberts et al., "From Challenging Assumptions to Measuring Effect..."

[18] Vanessa Scherman, Sarah J Howie, and Roel J Bosker, "Constructing Benchmarks for Monitoring Purposes: Evidence from South Africa," *Educational Research and Evaluation* 17, no. 6 (2011): 511–25.

[19] María José Hernández-Serrano et al., "Analysis of Digital Self-Presentation Practices and Profiles of Spanish Adolescents on Instagram and TikTok," *Journal of New Approaches in Educational Research* 11, no. 1 (January 15, 2022): 49, https://doi.org/10.7821/naer.2022.1.797.

[20] Nick Taylor et al., *National Report 2012: The State of Literacy Teaching and Learning in the Foundation Phase* (National Education Evaluation & Development Unit, 2013), http://www.saqa.org.za/docs/papers/2013/needu.pdf.

[21] Mark Coeckelbergh, "The Postdigital in Pandemic Times: A Comment on the Covid-19 Crisis and Its Political Epistemologies," *Postdigital Science and Education* 2, no. 3 (October 19, 2020): 547–50, https://doi.org/10.1007/s42438-020-00119-2.

[22] Fengfeng Ke, Kui Xie, and Ying Xie, "Game-based Learning Engagement: A Theory-and Data-driven Exploration," *British Journal of Educational Technology* 47, no. 6 (2016): 1183–1201.

[23] Santos, "Google Classroom: Beyond the Traditional Setting."

offer a plethora of educational resources such as online textbooks, video tutorials, and interactive lesson plans, bridging the gap between formal classroom instruction and self-directed learning. This connectivity also enables students to join a global community of educators and learners, fostering collaborative learning opportunities.[24] Furthermore, gamified elements in educational apps and platforms motivate students to engage with mathematical content more enthusiastically. Black, agrees with Khan, when the authors assert that through gamification, students can earn points, badges, and rewards as they progress through their mathematical journey, enhancing their intrinsic motivation to learn and excel in the subject.[25] Recent technological advancements have been especially crucial in supporting remote learning and ensuring access to quality mathematics education in remote or underserved areas.

Despite these benefits, integrating technology into mathematics education poses challenges.[26] Teachers need proper training to use these tools effectively, and concerns about data privacy and security arise. Additionally, not all students may have equal access to technology and the internet, leading to potential disparities in learning outcomes.[27] Nevertheless, the role of technology in transforming mathematics education remains a driving force towards a more data-driven and inclusive approach to teaching and learning.

Visualizing Mathematical Concepts with Interactive Tools and Simulations

Exploring interactive tools for visualizing mathematical concepts is a significant aspect of technology and digital platforms in data-driven mathematics teaching and learning. These interactive tools and simulations provide students with dynamic, visual representations of abstract mathematical ideas, making the learning process more engaging and accessible.[28] Interactive tools enable students to visualize complex mathematical concepts that may be difficult to grasp through traditional methods alone.[29] Visual representations help students build a deeper understanding of abstract ideas by providing concrete and interactive models that they can manipulate and explore.[30] Technology-based interactive tools and simulations are inherently engaging, as they encourage active participation and exploration. Students become more motivated to learn when they can interact with mathematical concepts and witness the impact of different variables and parameters in real-time.[31] Interactive tools provide a hands-on learning experience, allowing students to experiment and test their hypotheses. This active learning approach encourages students to develop problem-solving skills and a deeper sense of ownership over their learning process.

Additionally, interactive tools on digital platforms can be modified to accommodate different learning styles and paces.[32] With the ability to go at their own pace, repeat exercises as necessary, and get quick feedback, students may create individualized learning experiences. Interactive tools help bridge the gap between theoretical mathematical concepts and real-world applications. Downton, Cross and Auton aver that through the use of digital platforms, students can see how mathematical principles relate to practical scenarios, making mathematics more relevant and applicable to their lives.[33] Interactive tools can also be used to visualize data sets and statistical concepts, making data analysis more accessible and understandable. Students can dynamically interpret graphs and charts, facilitating a deeper comprehension of data-driven decision-making.[34]

Interactive technologies help students grasp concepts better by letting them interact with visual representations. Understanding and memory of essential ideas are improved by seeing mathematical concepts in action. Interactive tools frequently use both visual and audio components to accommodate various learning

[24] Hernández-Serrano et al., "Analysis of Digital Self-Presentation Practices and Profiles of Spanish Adolescents on Instagram and TikTok."
[25] Hasan Khan, "Constructivism: Towards a Paradigm Shift in Classroom Teaching & Learning."
[26] Petro Du Preez and Lesley Le Grange, "The COVID-19 Pandemic, Online Teaching/Learning, the Digital Divide and Epistemological Access," *Unpublished Paper* 1 (2020): 90–106; Jantjies, "Five Things South Africa Must Get Right for Technology in Schools to Work."
[27] Du Preez and Le Grange, "The COVID-19 Pandemic, Online Teaching/Learning, the Digital Divide and Epistemological Access."
[28] Ke, Xie, and Xie, "Game-based Learning Engagement: A Theory-and Data-driven Exploration."
[29] Sung Youl Park, Hae Deum Lee, and Soo Young Kim, "South Korean University Students' Mobile Learning Acceptance and Experience Based on the Perceived Attributes, System Quality and Resistance," *Innovations in Education and Teaching International* 55, no. 4 (2018): 450–58.
[30] Tamborg, "Improving Mathematics Teaching via Digital Platforms?...."
[31] Chen, "A Glimpse of the First Eight Months of the COVID-19 Literature on Microsoft Academic Graph…"; Susanta Mitra and Somsubhra Gupta, "Mobile Learning under Personal Cloud with a Virtualization Framework for Outcome Based Education," *Education and Information Technologies* 25, no. 3 (May 6, 2020): 2129–56, https://doi.org/10.1007/s10639-019-10043-z.
[32] Amine Hatun Ataş and Ömer Delialioğlu, "A Question–Answer System for Mobile Devices in Lecture-Based Instruction: A Qualitative Analysis of Student Engagement and Learning," *Interactive Learning Environments* 26, no. 1 (2018): 75–90; Ke, Xie, and Xie, "Game-based Learning Engagement: A Theory-and Data-driven Exploration."
[33] Downton, Cross, and Auton, "The Outcome of a Flipped Classroom Approach on Student Learning Experience."
[34] Downton, Cross, and Auton, "The Outcome of a Flipped Classroom Approach on Student Learning Experience."

styles. This multimodal strategy guarantees that a wider spectrum of students will profit from the engaging learning environment. To investigate mathematical concepts as a team, students can collaborate using interactive tools on digital platforms.[35] This encourages effective communication, critical thinking and teamwork. Teachers can collect real-time information on student performance and understanding by using interactive tools for formative assessment. This information can be used by teachers to pinpoint students' areas of need and identify learning gaps.[36]

Additionally, technology and digital platforms that incorporate interactive tools for visualizing mathematical concepts are invaluable resources for data-driven mathematics teaching and learning. These tools enhance engagement, facilitate hands-on learning, bridge theory and practice, and support personalized learning experiences.[37] By leveraging interactive tools, educators can help students develop a deeper understanding of mathematical concepts and cultivate essential problem-solving skills dynamically and excitingly.

THEORETICAL FRAMEWORK

This paper presents a theoretical framework for mathematics teaching and learning that revolves around the data-driven approach. This approach prioritizes the utilization of data to inform educational practices and elevate student performance. The framework draws support from the technology acceptance model proposed by Davis, highlighting that technology is not an isolated entity but rather embedded within social and organizational contexts.[38] Factors such as usability, ease of application and social impact significantly influence the adoption and effective use of technology in education. Moreover, this research incorporates the socio-cultural perspective, recognizing the critical role of considering social and cultural contexts when designing, developing, and implementing technology solutions for mathematics teaching and learning. Kanmani and Babu, assert that to enhance the effectiveness and relevance of educational technology, educators need to understand and embrace diverse cultural backgrounds and social influences as well as Data-driven Mathematics Teaching and Learning Practices within the Education System.[39] Data-driven learning emerges as a powerful approach that empowers educators to make well-informed decisions by collecting, analyzing, and leveraging data to identify students' needs, assess teaching effectiveness, and optimize the learning process. This process ultimately fosters personalized learning experiences and more targeted support for each student. With the increasing popularity of digital platforms, educators have found valuable tools to monitor student progress, measure their achievements and create tailored learning experiences.[40] The integration of digital platforms further facilitates a more dynamic and responsive teaching environment.[41] Additionally, this paper advocates for the integration of data-driven methodologies, technology acceptance insights, and socio-cultural considerations in mathematics teaching and learning. By leveraging these approaches and embracing digital platforms, educators can provide a more effective and personalized learning journey for students, ultimately improving educational outcomes and enhancing the overall learning experience.

METHODOLOGY

This study used a qualitative method to discuss the constructivist approach to learning. The authors discussed literature on three selected themes namely, Technology and Digital Platforms within the Education system, Data-driven Mathematics Teaching and Learning Practices and the South African Education System. Studies by Nqabeni; Alharbi and Drew and Mtebe and Raisamo explore technology-enhanced learning possibilities in education.[42] The use of data in teaching and learning has garnered significant attention, with scholars discussing

[35] Downton, Cross, and Auton, "The Outcome of a Flipped Classroom Approach on Student Learning Experience."
[36] Vally, "Education Inequality: The Dark Side of South Africa's Education System"; SACMEQ, "The SACMEQ Iv Project in South Africa: A Study of the Conditions of Schooling and the Quality of Education," August 2017.
[37] Taylor et al., *National Report 2012: The State of Literacy Teaching and Learning in the Foundation Phase*.
[38] Fred D. Davis, "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology," *MIS Quarterly* 13, no. 3 (September 1989): 319, https://doi.org/10.2307/249008.
[39] Kanmani and Babu, "Leveraging Technology in Outcome-Based Education."
[40] Park, Lee, and Kim, "South Korean University Students' Mobile Learning Acceptance and Experience Based on the Perceived Attributes, System Quality and Resistance."
[41] IT Web, "The Government Makes Provision for Learning during Lockdown."
[42] Nozuko Nqabeni, "Rethinking South African Higher Education Institutions Role Towards Curriculum Restructuring," *E-Journal of Humanities, Arts and Social Sciences (EHASS)* 4, no. 10 (2023): 1253–63; Saleh Alharbi and Steve Drew, "The Role of Self-Efficacy in Technology Acceptance," 2019, 1142–50, https://doi.org/10.1007/978-3-030-02686-8_85; Joel S. Mtebe and Roope Raisamo, "A Model for Assessing Learning Management System Success in Higher Education in Sub-Saharan Countries," *The Electronic Journal of Information Systems In Developing Countries* 61, no. 1 (February 5, 2014): 1–17, https://doi.org/10.1002/j.1681-4835.2014.tb00436.x.

how data can improve instructional decisions and student performance.[43] Chan and Sidhu suggest that data usage could enhance the overall quality of teaching and learning.[44] The South African education system, points out its high levels of inequality, particularly in terms of access to education and resources.[45] However, there is a growing recognition of the potential of technology and digital platforms in addressing some of these challenges.

DISCUSSIONS

This section discusses the three selected themes mentioned above. It also discusses utilizing data analytics to enhance mathematics curriculum and provides a model for leveraging technology in mathematics education.

Digital Platforms for Teaching Mathematics within the Education System

To facilitate access to education and enhance student learning outcomes, the South African Education system incorporates digital platforms. These platforms consist of the LMS, the Educational Resources Platform (ERP) and the Student Information System (SIS). The LMS serves as a centralized platform that fosters student learning, enables teacher communication and facilitates resource sharing.[46] Meanwhile, the ERP, also known as the Educational Resources Platform, provides access to the content of the South African curriculum. Specifically, the LMS Moodle, an open-source Learning Management System, empowers teachers to upload and distribute curriculum resources, create assessments and interact with students.[47] For managing student records, attendance and performance tracking, the Education system utilizes the Student Information System (SIS). The chosen SIS is OpenEMIS, an Open-Source Student Information System, which serves as a centralized platform for tracking student-related data.[48] Through the OpenEMIS platform, teachers can monitor student performance and provide real-time feedback to both students and parents. In the context of data-driven education and learning, technology plays a crucial role. It enables the collection, analysis and visualization of data, and in the end, promotes a data-oriented approach. Digital platforms, such as LMS, can effectively integrate data into instructional material planning and delivery.[49] However, the effectiveness of technology in promoting data-driven education depends on how well it aligns with pedagogy and content knowledge.[50]

Data-Driven Pedagogy in the Education System

The DBE uses data-driven pedagogy to enhance student learning outcomes. This approach utilizes data to inform teaching methods, monitor student progress, and optimize learning.[51] The system relies on formative assessments to gather student learning data, which in turn, informs teaching techniques and tracks student performance. The education system in South Africa has made commendable efforts to integrate technology into its framework to improve educational access and student achievements.[52] Nevertheless, there are obstacles such as insufficient infrastructure, inadequate teacher training, and unequal access to technology to effective technology integration in South African schools.[53] Despite these challenges, there are successful instances of technology integration in South African schools, such as utilizing mobile devices for data collection and analysis. Research indicates that employing digital platforms for data-driven teaching and learning can lead to

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[43] Sofia Moya and Mar Camacho, "Identifying the Key Success Factors for the Adoption of Mobile Learning," *Education and Information Technologies* 26 (2021): 3917–45; Gedala Mulliah Naidoo and Magdalene Kevisha Naidoo, "Digital Communication: Overcoming Digital Teaching and Learning Barriers During the COVID-19 Lockdown," in *Digital Pedagogies and the Transformation of Language Education* (IGI Global, 2021), 183–203.

[44] Chan Yuen Fook and Gurnam Kaur Sidhu, "Investigating Learning Challenges Faced by Students in Higher Education," *Procedia - Social and Behavioral Sciences* 186 (May 2015): 604–12, https://doi.org/10.1016/j.sbspro.2015.04.001.

[45] Fook and Sidhu, "Investigating Learning Challenges Faced by Students in Higher Education"; Jantjies, "Five Things South Africa Must Get Right for Technology in Schools to Work."

[46] P. Padayachee, S. Wagner-Welsh, and H. Johannes, "Online Assessment in Moodle: A Framework for Supporting Our Students," *South African Journal of Higher Education* 32, no. 5 (October 2018), https://doi.org/10.20853/32-5-2599; Pamela Roberts, "Higher Education Curriculum Orientations and the Implications for Institutional Curriculum Change," *Teaching in Higher Education* 20, no. 5 (July 4, 2015): 542–55, https://doi.org/10.1080/13562517.2015.1036731.

[47] Padayachee, Wagner-Welsh, and Johannes, "Online Assessment in Moodle: A Framework for Supporting Our Students."

[48] Lin Lin and Tristan Johnson, "Shifting to Digital: Informing the Rapid Development, Deployment, and Future of Teaching and Learning," *Educational Technology Research and Development* 69, no. 1 (February 2, 2021): 1–5, https://doi.org/10.1007/s11423-021-09960-z.

[49] Padayachee, Wagner-Welsh, and Johannes, "Online Assessment in Moodle: A Framework for Supporting Our Students."

[50] Matthew Koehler and Punya Mishra, "What Is Technological Pedagogical Content Knowledge (TPACK)?," *Contemporary Issues in Technology and Teacher Education* 9, no. 1 (2009): 60–70.

[51] Taylor et al., *National Report 2012: The State of Literacy Teaching and Learning in the Foundation Phase*.

[52] Department of Education [DoE], *White Paper 7 on E-Education*.

[53] Vally, "Education Inequality: The Dark Side of South Africa's Education System"; Bekithemba Dube, "Rural Online Learning in the Context of COVID 19 in South Africa: Evoking an Inclusive Education Approach," *REMIE: Multidisciplinary Journal of Educational Research* 10, no. 2 (2020): 135–57.

enhanced student outcomes. In a study conducted by, teachers who utilized digital platforms to track student progress reported higher student engagement and improved academic performance.[54] In a country grappling with challenges like limited funding, scarcity of teachers and inadequate infrastructure, leveraging technology for data-driven teaching and learning can help bridge the education gap in South Africa. Santos conducted a study where teachers in South Africa reported positive impacts on student engagement, performance and motivation through the use of digital platforms.[55] Dube agrees with, Nqabeni and Buka by stating that South Africa's education system faces various obstacles, including resource limitations, under-resourced schools and restricted technology access.[56] As highlighted by Nqabeni et, al., the system is characterized by significant inequality, particularly concerning education and resources.[57] However, there is an increasing acknowledgment of technology and digital platforms' potential to address some of these challenges.

Data-Driven Mathematics Teacher Professional Development

Teacher professional development for data-driven mathematics instruction is essential for effectively integrating technology and digital platforms into the teaching and learning process. As data-driven approaches become more prevalent in education, educators must develop the necessary skills and knowledge to leverage technology and use data effectively in their mathematics classrooms.[58] Technology offers a wide range of data analysis tools and software that can help teachers interpret and utilize student data effectively. Professional development programs empowering teachers to analyze data, identify trends, and make informed instructional decisions can provide training on these tools. Teacher professional development can include hands-on workshops and webinars where educators learn how to integrate technology and digital platforms into their mathematics instruction. These sessions can focus on specific tools and strategies that promote data-driven teaching and learning.

Digital platforms can host specialized courses and modules dedicated to data-driven mathematics instruction. These online resources allow teachers to access professional development content at their own pace and convenience, catering to individual learning preferences.[59] Technology facilitates the formation of collaborative learning communities for teachers. Educators can share best practices, discuss challenges, and exchange ideas on incorporating data-driven approaches in mathematics teaching. Digital platforms enable these communities to connect and interact, irrespective of geographic limitations.[60] Professional development can train teachers to use data analysis for student assessment. Educators can learn how to create data-informed assessments and interpret the results to identify individual student needs and adapt their instructional strategies accordingly. Technology allows teachers to differentiate instructions based on students' data profiles. Through professional development, educators can learn how to use data to personalize learning experiences and ensure that each student receives appropriate support and challenges.

Teachers can be trained to effectively monitor student progress using digital platforms and data analysis tools.[61] This helps educators track individual performance, identify struggling students and provide timely interventions. Professional development in data-driven mathematics instruction should also address ethical considerations, data privacy and security. Teachers need to understand best practices for handling and protecting student data responsibly. Technology can be utilized to help teachers engage in reflective practice, according to.[62] Through data analysis, educators can evaluate the efficacy of their teaching strategies and implement data-driven changes to their education.[63] Professional development ensures that instructors stay current on the newest

[54] Fook and Sidhu, "Investigating Learning Challenges Faced by Students in Higher Education."
[55] Santos, "Google Classroom: Beyond the Traditional Setting."
[56] Dube, "Rural Online Learning in the Context of COVID 19 in South Africa: Evoking an Inclusive Education Approach"; Nozuko Nqabeni and Andrea Mqondiso Buka, "Post Covid-19: Exploring the Decolonisation Factor in a Mathematics Classroom in South African Schools," *E-Journal of Humanities, Arts and Social Sciences*, March 17, 2023, 287–99, https://doi.org/10.38159/ehass.2023439.
[57] Nqabeni, "Rethinking South African Higher Education Institutions Role Towards Curriculum Restructuring."
[58] Naidoo and Naidoo, "Digital Communication: Overcoming Digital Teaching and Learning Barriers During the COVID-19 Lockdown"; Vally, "Education Inequality: The Dark Side of South Africa's Education System."
[59] R. Dlamini and N. Ndzinisa, "Universities Trailing behind: Unquestioned Epistemological Foundations Constraining the Transition to Online Instructional Delivery and Learning," *South African Journal of Higher Education* 34, no. 6 (December 2020), https://doi.org/10.20853/34-6-4073.
[60] Santos, "Google Classroom: Beyond the Traditional Setting."
[61] Santos, "Google Classroom: Beyond the Traditional Setting."
[62] Lin and Johnson, "Shifting to Digital: Informing the Rapid Development, Deployment, and Future of Teaching and Learning."
[63] Md Nazirul Islam Sarker et al., "Leveraging Digital Technology for Better Learning and Education: A Systematic Literature Review," *International Journal of Information and Education Technology* 9, no. 7 (2019): 453–61, https://doi.org/10.18178/ijiet.2019.9.7.1246.

resources and trends in data-driven mathematics instruction as technology and digital platforms continue to advance.

Utilizing Data Analytics to Enhance Mathematics Curriculum

Leveraging data analytics to enhance instructional design is a powerful application of technology and digital platforms in data-driven mathematics teaching and learning. Data analytics involves the systematic analysis of student data, learning patterns and performance metrics to gain valuable insights into how students interact with mathematical concepts and content.[64] By analyzing student mathematics performance data, teachers can identify common learning gaps and misconceptions.[65] These insights enable instructional designers to focus on specific areas that students find challenging. Addressing these gaps with targeted instructional materials and interventions ensures that students receive the support they need to overcome difficulties and build a solid foundation in mathematics.[66]

Data analytics allows digital platforms to dynamically adjust the delivery of content based on individual student progress and understanding. The platform can automatically recommend appropriate lessons, exercises and examples based on each student's performance, ensuring that they are appropriately challenged and engaged throughout their learning journey. Data analytics enables the creation of personalized learning paths for each student. Tamborg, states that through understanding students' strengths, weaknesses, and learning preferences, curriculum designers can develop customized sequences of content that cater to the individual needs of students.[67] This personalized approach fosters a deeper understanding of mathematical concepts and promotes self-directed learning. Technology and data analytics facilitate continuous formative assessment and provide instant feedback to students which helps them to correct errors and reinforces their understanding, promoting a more effective learning process.[68] As students engage in digital learning activities, their responses are analyzed in real-time and feedback is provided instantly.[69]

By helping teachers and instructional designers keep track of how students are doing educators can spot patterns and trends in student performance, so to make effective decisions about how real certain instructional strategies and content are.[70] Schools may determine which resources and teaching techniques are most effective for their students using data analytics, allowing them to concentrate their efforts and resources on those that will have the greatest positive effects on student learning.[71] Data analytics can aid educators in improving their methods for instructing and understanding mathematics. Educators can modify their materials to meet students' evolving needs and keep up with the most recent developments in teaching and learning by taking a close look at student performance, and how students interact with the material and other data. By incorporating data into instructional design, teachers can individualize instruction, provide insightful information about student learning patterns, and support evidence-based decision-making.[72] By integrating data-driven strategies with technology and digital platforms, educators can create more effective and engaging learning experiences, empowering students to succeed in their mathematical pursuits.[73]

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[64] Tamborg, "Improving Mathematics Teaching via Digital Platforms? Implementation Processes Seen through the Lens of Instrumental Genesis"; Kanmani and Babu, "Leveraging Technology in Outcome-Based Education"; Roberts, "Higher Education Curriculum Orientations and the Implications for Institutional Curriculum Change."

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[66] Tamborg, "Improving Mathematics Teaching via Digital Platforms? Implementation Processes Seen through the Lens of Instrumental Genesis"; N C Burbules and T A Callister, *Watch IT: The Risks and Promises of New Information Technologies* (Boulder, CO: Westview, 2000).

[67] Tamborg, "Improving Mathematics Teaching via Digital Platforms? Implementation Processes Seen through the Lens of Instrumental Genesis."

[68] Sarker et al., "Leveraging Digital Technology for Better Learning and Education: A Systematic Literature Review."

[69] Hatun Ataş and Delialioğlu, "A Question–Answer System for Mobile Devices in Lecture-Based Instruction: A Qualitative Analysis of Student Engagement and Learning."

[70] Burbules and Callister, *Watch IT: The Risks and Promises of New Information Technologies.*

[71] Dlamini and Ndzinisa, "Universities Trailing behind: Unquestioned Epistemological Foundations Constraining the Transition to Online Instructional Delivery and Learning"; Hatun Ataş and Delialioğlu, "A Question–Answer System for Mobile Devices in Lecture-Based Instruction: A Qualitative Analysis of Student Engagement and Learning."

[72] Tamborg, "Improving Mathematics Teaching via Digital Platforms? Implementation Processes Seen through the Lens of Instrumental Genesis."

[73] Mitra and Gupta, "Mobile Learning under Personal Cloud with a Virtualization Framework for Outcome Based Education."

The Process of Leveraging Technology in Mathematics Education

Inputs, tools, approaches and delivery are all part of the model of leveraging digital technology-based learning developed through this study (Fig. 1). The article deals with the entire process of leveraging technology in mathematics education.[74] The following sections describe this in detail as shown in the following figures:

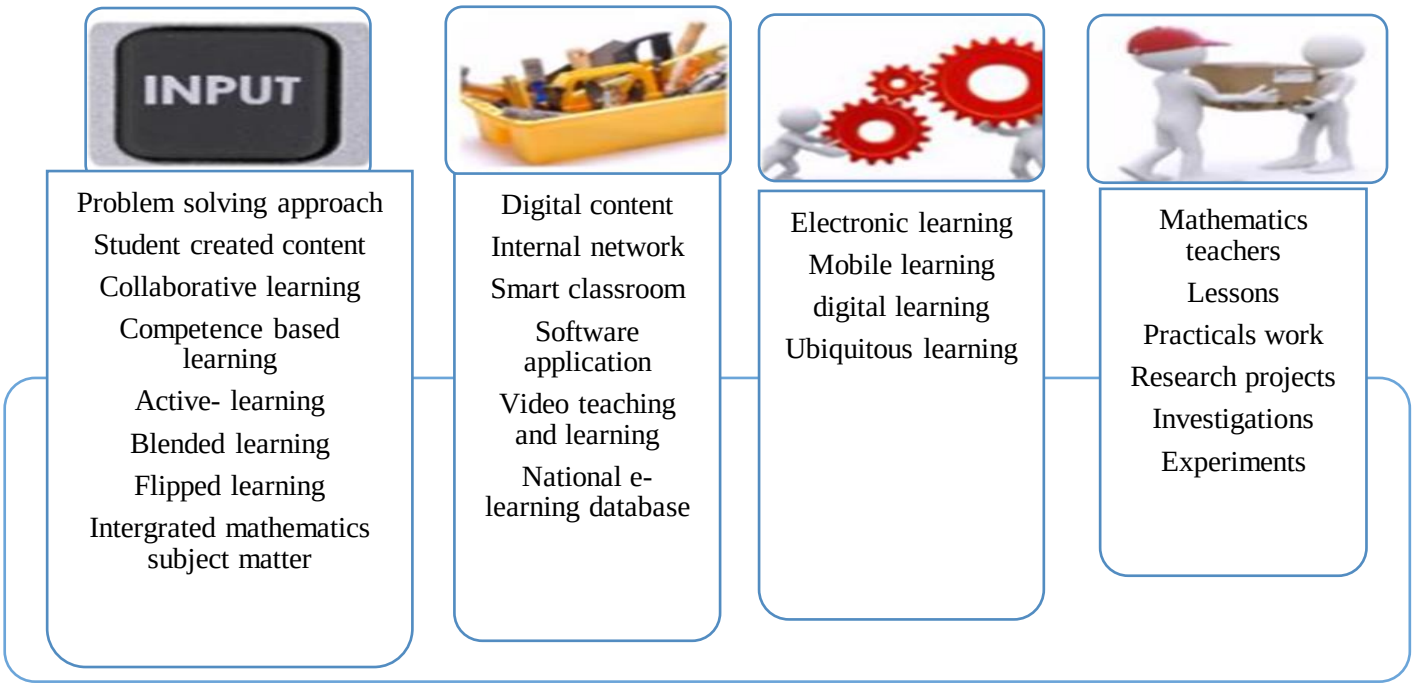

Fig. 1. Model of leveraging digital technology-based learning[75]

Four different portions of the section address the research findings. The first part of the paper discusses various approaches as learning input through the analysis of studies that are based on primary data as presented in the contextual background. The second part discusses approaches for ensuring employing technology in learning and is based on the theoretical framework and literature review of the paper as secondary data and systematic reviews. The third part describes the tools for effective technology leveraging mathematics learning and states: Digital Platforms for Mathematics Teaching within the Educational System as well as Data-Driven Pedagogy in the Educational System The fourth part explains the delivery method of learning through the lens of Data-driven mathematics teacher professional development and Utilization of data analytics to enhance mathematics curriculum.

RECOMMENDATIONS

This paper recommends that South African schools incorporate technology and data-driven approaches into their national mathematics curriculum. Moreover, the study recommends that mathematics teachers should be provided with ongoing professional development opportunities to improve their digital literacy skills and pedagogical skills in order to integrate technology and that they should be provided with ongoing support and resources to stay abreast of technology changes. To ensure equitable learning opportunities, this article advocates for improving teachers' access to digital resources and devices, especially in underserved areas, as well as policies and initiatives that ensure equitable access to technology and digital devices for all students, regardless of socioeconomic status. The paper suggests partnerships with tech companies or government subsidies to make technology more affordable for schools. It advocates for customized digital learning platforms, data-driven learning experiences, formative assessment, real-time feedback, collaboration among teachers and schools and involving parents and the community in technology-enhanced mathematics education.

[74] Sarker et al., "Leveraging Digital Technology for Better Learning and Education: A Systematic Literature Review."
[75] Sarker et al., "Leveraging Digital Technology for Better Learning and Education: A Systematic Literature Review."

It also emphasizes the importance of collaboration. Furthermore, the collaboration between government agencies, educational institutions and stakeholders to implement technology in mathematics education is recommended in this paper. The article also suggests that a monitoring system be implemented, ongoing research be done, infrastructure investments be made, and that parents and local communities be involved in understanding and supporting schools' use of technology.

CONCLUSION

This paper has revealed that when implemented thoughtfully, data-driven digital platforms can significantly enhance mathematics teaching and learning and this will lead to personalized, evidence-based and impactful educational experiences. In the realm of mathematics education, data-driven approaches for personalized learning have become increasingly vital due to their potential to improve student engagement, understanding, and overall academic achievement. By harnessing technology and digital platforms, educators can craft tailored learning experiences that empower students to excel and foster a lifelong passion for mathematics. The integration of data analytics into the mathematics curriculum enhances instructional design by providing valuable insights into student learning patterns, enabling individualized instruction and guiding evidence-based decision-making. When combined with technology and digital platforms, data-driven strategies create more effective and engaging learning experiences, bolstering students' success in their mathematical pursuits. The study emphasizes the critical role of technology and digital platforms in supporting teachers in interpreting and applying data insights in mathematics teaching and learning. Equipped with data visualization tools, analysis software, customized reports and real-time data access, technology empowers educators to make data-informed decisions for personalized and effective instruction. To further aid teachers, professional learning communities, workshops, and coaching services offer support and training in utilizing data insights to enhance student outcomes and mathematics education. Moreover, technology and digital platforms provide valuable resources for teacher professional development in data-driven mathematics instruction. By offering access to data analysis tools, facilitating collaborative learning communities, and providing training on effective data use, educators can develop the skills and knowledge necessary to successfully integrate data-driven approaches into their mathematics classrooms. This paper has revealed that teachers can create more personalized and impactful learning experiences for their students, fostering improved academic outcomes in mathematics education. In conclusion, the wealth of research supports the integration of technology and digital platforms for data-driven learning and teaching, showcasing their potential to revolutionize education and improve student outcomes.

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