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(Research Article)

Enhancing mathematics achievement in underserved high schools through data-driven instructional strategies: A case study approach

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Abstract

This paper discusses data-driven instructional practices to enhance mathematics performance in disadvantaged high schools. The study employs the mixed-methods case study design to determine how data collection, analysis, and instructional adaptation can help resolve long-standing achievement gaps in resource-scarce educational settings. The research is based on three urban high schools with the majority of students being low-income and historically marginalized. It explores the role of formative assessment, real-time instructional changes, and collaborative teacher practices based on student performance data in better academic performance. The standardized test scores are used to analyze quantitative data and to gather qualitative information through interviews and observation of the teachers to give a complete picture of the effectiveness of data-driven instruction (DDI). The results indicate a high level of improvements in student outcomes and engagement, as well as some implementation obstacles that have been revealed, including the low level of teacher training, infrastructure limitations, and data literacy issues. The research provides effective guidelines on how DDI can be scaled in other underserved settings by investing in the strategy and supporting it with long-term professional assistance.

Keywords: Data-Driven; High Schools; Mathematics; Strategies; Underserved

1. Introduction

The continued lack of equity in mathematics performance among learners in underserved high schools and their more privileged peers has become a burning issue in education systems across the world. These gaps can be caused by structural inequities, including insufficient funding, poorly qualified teaching personnel, and a lack of access to academic support systems (Ajiga et al., 2025; Zeeshan, 2024). In addition to adverse mental health outcomes, recent reports further tie teacher burnout to persistent teacher shortages, particularly in the field of special education and in high-need teaching areas such as mathematics (IES STAFF, 2023; Masuka et al., 2024). Specifically, the socioeconomically disadvantaged communities encounter numerous challenges that affect their mathematical proficiency, such as the lack of resources and exposure to more intensive teaching methods (Abdullahi and Umar, 2024; Regis, Nyamu, and Wambasi, 2025).

Against this backdrop, data-driven instruction (DDI) is one of the promising methods that can be used to enhance the performance of students, particularly in mathematics. DDI is a strategic application of student performance data, including test scores and formative assessments, to guide and make changes to teaching practices in real-time (Chandler, 2020; Ahmad et al., 2024). Research indicates that educators can address achievement gaps by providing targeted instruction to the individual learning needs when they have access to timely data and have the knowledge to analyze it (Gullo, 2013; Summers, 2023). Although DDI is becoming increasingly popular, the way it is implemented in

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underserved high schools is not consistent, and the main reason is the existence of such barriers as teacher resistance, the absence of training, and poor infrastructure (Datnow and Hubbard, 2015; Akosah, Arthur, and Obeng, 2025).

The proposed study will investigate the role of data-driven instructional methods in improving mathematics performance in underserved high schools using a case study design.

The objectives are threefold:

- To identify specific DDI strategies employed in selected schools.
- To assess their impact on student mathematics performance
- To examine the challenges encountered during implementation.

2. Literature Review

2.1. Challenges in Underserved High Schools

Underprivileged high schools, especially in low-income and rural schools, are still facing various structural issues that act as barriers to academic achievement in mathematics. One of the most important problems is the consistent resource deficiency, such as the lack of instructional resources, old textbooks, poor access to technology, and inadequately funded facilities (Ajiga et al., 2025; Zeeshan, 2024). Such constraints make students less inclined to learn mathematics in a substantial manner, which leads to the resulting performance disparities between them and their more privileged counterparts.

The other issue that has been lingering is the lack of qualified and experienced mathematics teachers. This is especially evident in underserved schools, where workforce challenges lead to high turnover, oversized classes, and compromised instruction (Abdullahi and Umar, 2024; Akosah, Arthur, and Obeng, 2025). Teachers with low preparation tend to have a low level of pedagogical content knowledge and do not know how to present difficult mathematical concepts.

Akosah et al. (2025) emphasize the role of teacher self-efficacy that mediates the outcomes of student achievements in mathematics significantly, which highlights the role of well-trained educators. Additionally, another complication of the problem is the mental aspect of educators serving in underserved schools that are usually highly stressed and have little to no support, especially when serving students with disabilities (Masuka et al., 2024). Special educator shortage has also been mentioned as a systemic issue related to higher burnout and lower student engagement (IES STAFF, 2023).

These problems are further complicated by student preparedness gaps. There is a relatively large number of learners who join high school without basic mathematical literacy skills because of the lack of educational support in their previous classes. Such a lack usually leads to the lack of confidence, motivation, and interest in math classes (Sumaila, 2025). The cultural and social perception of mathematics is also involved, as Alam and Mohanty (2023) state, because long-standing beliefs about the grouping of abilities and perceived inability to learn can demotivate students from continuing with the difficult work.

Furthermore, sociological conditions, including poverty, food insecurity, and family instability, influence the focus and attendance of students negatively (Chikwe et al., 2024). The barriers are contextual and restrain instructional time and learning efficacy. Datnow and Hubbard (2015) also mention that in such situations, a culture of data use is hard to develop in many schools, undermining the work on better outcomes further. Collectively, all these interrelated issues emphasize the need to consider innovative teaching methods that are responsive to the specific needs of underserved populations. The second part discusses why data-driven instruction (DDI) can be used as a solution to these issues.

2.2. Education Data-Driven Instruction (DDI)

Data-driven instruction (DDI) has become a strategic educational approach relying on the data on performance to inform the teaching process, enhance lesson planning, and fill gaps in real time. Ahmad et al. (2024) define DDI as the use of quantitative and qualitative data (e.g., test scores, formative assessment, and student feedback) to guide specific interventions. The essential elements are continuous formative assessment, real-time instructional changes, and teacher collaboration in the process of data-driven action interpretation (Chandler, 2020; Summers, 2023).

The core of DDI is formative assessments, which allow teachers to assess the conceptual understanding of students on a regular basis and modify the instruction before the misconception sets in. According to Summers (2023), the feedback loop that gives power to retention and skill acquisition is supported by frequent low-stakes testing. On the same note, Gullo (2013) also points out that assessment data should be used to inform early instructional practices, especially in areas that necessitate cumulative knowledge like mathematics.

Real-time instructional adaptation is another key component of DDI. Data is used to differentiate instruction in which students are grouped according to the trends in their performance and the lessons are customized to suit different learning needs (Abdullahi and Umar, 2024; Vacalares, Elbanbuena, and Comon, 2024). Predictive analytics platforms and other data tools allow the early identification of at-risk students, as well as timely interventions (Learnomics Media, 2024; SchoolAnalytix, 2024). Matende et al. (2025) initiate an intervention model at the district-wide level involving the use of predictive analytics to target the students at risk in secondary math programs, especially in urban and rural districts. As an illustration, Alalawi et al. (2024) show how predictive models can help anticipate academic difficulties and enable educators to create support strategies proactively.

The positive effects of DDI on enhancing student performance are well known. Ajiga et al. (2025) argue that DDI leads to a substantial rise in involvement, achievement in tests, and confidence among students, particularly in schools with limited resources. Results of the study by Rogers (2018) revealed that teachers introducing DDI to the classroom in middle school math classes have reported tangible improvement of achievement and involvement in the classroom. In addition, data-informed teaching also encourages transparency and accountability in planning instruction (Bachmann et al., 2022), which helps create a more equitable learning environment.

However, effective implementation depends heavily on teacher capacity. Datnow and Hubbard (2015) warn that teachers do not always have the skills and time to interpret data in a meaningful way, and Pearson (2014) states that leadership support and collaborative data cultures are the keys to DDI success. Luzano (2024) also states that AI and data systems are to be used as a complement to, rather than a substitute for, human judgment in the assessment practice. Therefore, DDI provides a formal evidence-based model to enhance instruction and learning outcomes. The second section is a review of the specific application of DDI in the field of mathematics education and what has been found and what is lacking in the research.

2.3. Previous Studies on DDI in Mathematics

Available literature offers strong support to the utilization of DDI as an effective strategy in enhancing mathematics performance, especially in low-income school environments. In their case study in Sokoto State, Abdullahi and Umar (2024) showed that data-informed, technology-enhanced differentiation resulted in considerable improvement in student outcomes. Their results highlight the importance of personalized interventions that are powered by real-time analytics and formative assessment.

Such results were also noted by Ajiga et al. (2025) in the underserved schools in the U.S., where the utilization of student performance data led to differentiated instruction and increased standardized test performance. They also emphasize that leadership buy-in and teacher training are important to maintain data use in their study. On the same note, Akosah, Arthur, and Obeng (2025) observed that teacher self-efficacy is critical in developing effective instructional action based on the data insights, particularly in math classrooms.

Karpiinski and Pietro (2024) reviewed the best practices in mathematics instruction and discovered that data-driven lesson design, peer-to-peer, and professional development have strong correlations with student achievement. They state that numerous instructional initiatives are reactive and ineffective unless there are organized data analysis procedures.

In the meantime, Bayore and Cajandig (2025) examined the connection between the concepts of critical thinking, creativity, and data-informed pedagogy in math education. Their serial research revealed that scaffolding through data promoted more conceptual learning, particularly in those students who initially had low engagement.

However, several studies also reveal persistent gaps. An example is that Chandler (2020) discovered that although the benefits of DDI are widely known, the application is inconsistent in schools. A lot of teachers do not have access to quality data systems, and some even doubt the effectiveness of continuous testing. Lin et al. (2024) share these concerns, warning that data overload and low data literacy may undermine data-driven instructional decision-making.

Moreover, DDI research usually fails to take into account cultural and contextual peculiarities. Alam and Mohanty (2023) contend that, unless the social nature of ability grouping and implicit biases is recognized, DDI can actually perpetuate achievement gaps. Moreover, Jeri and Masuka (2025) discuss the roles of families and parents in the context of academic interventions, suggesting that the DDI interventions must be set in the environment of overall student support, at least when it comes to students with disabilities. Luzano (2024) adds additional issues regarding the ethical aspects of AI-driven assessment, including student profiling and algorithmic bias, especially in high-stakes settings.

Another noticeable gap lies in longitudinal impact studies. Although the improved math scores in the short term are often reported, little is known about the effects of long-term DDI practice on long-term achievements and attitudes towards mathematics. According to Sujatha and Vinayakan (2022), new instructional frameworks should not only be judged based on short-term academic outcomes but also on their ability to develop long-term mathematical literacy.

Finally, teacher perceptions play a pivotal role. According to Rogers (2018), in under-resourced environments, some instructors, particularly those who work in environments with limited resources, consider DDI practices to be a burden because of time constraints and insufficient support. Datnow and Hubbard (2015) support their statement with the necessity to organize specific professional development activities to strengthen the analytical and pedagogical confidence of teachers.

3. Methodology

The current research will be conducted in the form of a case study using both qualitative and quantitative research methods to address how data-driven instructional strategies can be used to improve mathematics achievement in underserved high schools. The mixed-methods design is specifically suitable to explore complex educational phenomena in the context of their real life because it allows analyzing not only measurable results but also the life experiences of stakeholders (Ajiga et al., 2025; Akosah, Arthur, and Obeng, 2025). This method allows integrating the quantitative data on student achievement with the qualitative data presented by teachers and teacher-student interactions to provide a complex picture of the data-driven instruction (DDI) functioning in practice.

The study was carried out in three of the public high schools in the socioeconomically disadvantaged communities. These schools were specifically chosen on the grounds of poverty levels, poor standardized math scores, and low access to education technologies. The sample included around 180 students in grades 9-11 and 15 teachers of mathematics, with different ethnicities and teaching experience. The majority of the students had access to few learning materials at home, and almost 40 percent of the instructors had fewer than five years of experience in the classroom. These demographics match national patterns of underserved school contexts, in which systematic obstacles can have an impact on academic performance (Zeeshan, 2024; Chandler, 2020).

Three main methods of data collection were employed: student test scores, semi-structured teacher interviews, and classroom observations. The intervention was measured by use of pre- and post-intervention mathematics tests, which were conducted within one academic term to determine the changes in student performance. These tests were constructed in a way that they correspond to the requirements of the curriculum and consisted of procedural and conceptual tasks. Interviews with teachers gave qualitative information about the instructional practice, views on DDI, and difficulties in the implementation process. Open-ended questions were used so that deeper research could be done on teacher attitudes and strategies. The classroom observations took place once every two weeks and were aimed at the formative assessments, differentiation techniques, and collaborative planning. Observational protocols were modified based on the existing frameworks applicable in the studies of instructional effectiveness (Pearson, 2014; Summers, 2023).

Thematic analysis and statistical methods were used in the analysis of data. Interviews and observations were transcribed and coded in a grounded theory approach whereby the important themes were extracted through the data instead of being predetermined (Datnow and Hubbard, 2015). This allowed identifying common patterns of teacher behaviors, instructional changes, and data use. The most common themes were differentiated instruction on the basis of the assessment data, data reviews conducted by the teaching teams, and the level of comfort regarding digital tools. The descriptive statistics and paired t-tests were used to analyze the quantitative data of student assessments in terms of the changes in the mean performance scores before and after the implementation of DDI. This allowed finding out statistically significant trends that could be associated with the observed changes in instruction in qualitative data (Abdullahi and Umar, 2024; Ajiga et al., 2025).

4. Findings

4.1. Pre-Implementation Math Performance

At the onset of the academic term, baseline data that measured the overall student achievement in mathematics indicated that there was a wide disparity in student mathematics achievement at the three underserved high schools. Diagnostic tests revealed that only 31 percent of the students proved competent in grade-level mathematics skills, and most of them had problems with simple concepts like fractions, algebraic expressions, and problem-solving techniques. These outcomes were indicative of years of systemic learning deficits that might have occurred through irregular teaching and a lack of access to external learning support (Sumaila, 2025; Zeeshan, 2024). The achievement data also indicated the existence of disparities among subgroups, with English language learners and students with special needs having the worst performance levels.

The interviews with teachers showed that the majority of students had no prior knowledge when they came to their classrooms, making it hard to teach at grade level. These results are in line with the existing literature indicating the academic difficulties of students in underserved settings, where the socioeconomic disadvantage tends to be converted into low access to high-quality education and low preparedness (Ajiga et al., 2025; Abdullahi and Umar, 2024). It is worth noting that few teachers indicated that they used assessment data on a systematic basis before this research, indicating a possible lack of systematic instructional planning and little reliance on feedback loops in real time.

4.2. Key Data-Driven Strategies Used

After the adoption of data-driven instructional practices, some specific approaches became the focus of classroom activities. The first one is that formative assessment was introduced as a prominent feature of instructional planning. The teachers used biweekly low-stakes quizzes and in-class assignments that gave the students instant feedback on their knowledge. These tests enabled monitoring of progress to be done continuously and real-time changes in instructions to be made. According to Gullo (2013) and Summers (2023), formative assessment is an essential part of successful DDI, which provides educators with prompt information about individual and group learning patterns.

Second, assessment data were used extensively to differentiate the instructions. Teachers utilized data of student performance to group learners according to levels of proficiency and differentiate lessons to suit a wide range of abilities. This involved giving scaffolded work and additional material to students who are struggling and extending work to students who are doing above grade level. A major transition in instructional delivery was observed in the classroom, where a large number of educators abandoned the one-size-fits-all approach. Such practices correspond to the results of Abdullahi and Umar (2024) and Vacalares et al. (2024), who observed that data-informed differentiation ensures a higher level of engagement among students and meets various learning needs.

Third, data analysis performed by teachers was found to be one of the leading factors in the improvement of instructions. The weekly planning sessions were implemented where teaching teams analyzed the data on student performance, shared their challenges, and co-created strategies. The cooperative culture helped in shared responsibility and enhanced instructional coherence in the classrooms. Teachers noted that such conversations helped them better understand data and use the findings to plan lessons—reflecting the same significance of data teams mentioned by Datnow and Hubbard (2015) and Rogers (2018).

As well, schools started to incorporate fundamental data visualization tools in order to facilitate analysis. Most teachers were not very familiar with such tools before the study, but peer-led training and mentorship contributed to the development of data literacy in the long term. According to Ahmad et al. (2024) and Learnomics Media (2024), digital tools have the potential to help teachers tremendously in recognizing patterns and locating interventions when accompanied by proper training.

4.3. Impact on Student Achievement

Follow-up tests showed a significant increase in the performance of students in mathematics. Mean proficiency levels increased by 25 percentage points (31% to 56%) in the three schools, and the greatest increases were among students who had previously scored in the lowest quartile. These gains were statistically significant ($p < 0.05$) and were reinforced by the qualitative feedback of the students and teachers. Students reported feeling more confident and enjoying math more, saying that they made progress due to better explanations, more feedback, and various types of support.

The observed improvements can be aligned with the previous studies that proved the efficacy of DDI in enhancing the outcomes of students, especially in resource-limited settings (Ajiga et al., 2025; Akosah, Arthur, and Obeng, 2025). Instruction-performance alignment seemed to close the learning gaps faster compared to the conventional teaching approaches. The results also support the claim by Karpiinski and Pietro (2024) that long-term data-driven instructional activities have quantifiable academic outcomes once they are consistently applied.

In addition to academic performance, classroom engagement increased substantially. According to teachers, students were more willing to attend lessons, complete their assignments, and seek help when necessary. Observation in the classrooms showed greater interaction, fewer behavioral disturbances, and an overall improved learning environment. These results are consistent with much wider data offered by Bayore and Cajandig (2025), who associate the use of DDI with greater motivation of students and the responsiveness of the classroom.

However, the implementation process was not without challenges. Initial teacher resistance to the use of data was one of the major obstacles. Others were skeptical regarding the usefulness of frequent testing and stated that they were overloaded with the new workload of data collection and data analysis. These issues are reflected in the findings of Chandler (2020) and Datnow and Hubbard (2015), who cited teacher buy-in and time as the ongoing challenges of DDI adoption.

The other challenge was the data literacy differentiation of teachers.

Some of them were quick to adjust, but some had difficulties with understanding performance measures and converting them into teaching strategies. Such a gap necessitates continuous professional development, as proposed by Pearson (2014) and Alalawi et al. (2024), who suggest that data tools and their use will only benefit the educators when they possess the competencies and confidence in using the data tools.

Infrastructure limitations also posed obstacles. Not every classroom was provided with stable internet and equipment to conduct digital tests, and schools did not have unified systems to store and exchange student data. These results are consistent with those of Zeeshan (2024) and Chikwe et al. (2024), who point out that the scalability of DDI is frequently restricted by technological limitations in low-resource circumstances. All these challenges notwithstanding, the performance of the strategies was largely positive. The teamwork and the gradual implementation of the data tools enabled the gradual change of the instructional culture.

5. Discussion

5.1. Interpretation of Findings

The results of the present study emphasize that data-driven instruction (DDI) can be a critical contributor to the improvement of mathematics achievement at underserved high schools. The significant increase in student proficiency, from 31 to 56 percent, shows the success of the real-time performance data in driving and individualizing instruction. DDI allowed teachers to become responsive to the needs of students, implementing regular formative assessments, interventions, and planning lessons together. The findings are in line with the findings of Ajiga et al. (2025), which indicated similar improvement in underserved communities in the U.S. by using data-informed strategies. Furthermore, the enhancement of the student engagement and the participation in the classroom is consistent with the study by Bayore and Cajandig (2025), in which the authors associate DDI with the development of learner motivation and critical thinking.

The collaboration of teachers in data analysis was of utmost importance in the adaptation of instructions and consistency in different classrooms. According to Datnow and Hubbard (2015), collaborative interpretation of data promotes a sense of shared responsibility and assists educators in improving their practice. This point of view is supported by the results of this research, as it has been shown that instructional decisions became more strategic due to the weekly data review meetings. The findings also correspond to the larger body of research on the positive effects of formative assessment on improving instruction (Summers, 2023; Gullo, 2013).

Notably, the research extends the body of knowledge by recording how DDI can be operationalized even in environments that are limited in infrastructure and resources. Although most of the literature accentuates DDI in more well-equipped schools, the case study demonstrates that even minimal tools in the hands of dedicated instructors can bring significant results. These results are similar to the work by Zeeshan (2024), who stated that pedagogical innovation may offset material shortages when it is applied with a purpose and consistency.

5.2. Barriers to Implementation

Although DDI was successful, its implementation was not exempt from challenges. The shortage of proper teacher training was the most outstanding obstacle. Some teachers were eager to learn data analysis tools as well as strategies, but others had problems interpreting the performance metrics or incorporating them in the lesson planning process. Such data literacy is a well-known difference in the literature. According to Ahmad et al. (2024) and Alalawi et al. (2024), lack of knowledge in the domain of analytics means that teachers are less inclined to use DDI systems effectively.

Resistance to change also emerged as a key barrier. A few instructors considered regular evaluations as a kind of burden and doubted the worth of data-driven instruction. The same feelings are described in the works by Chandler (2020) and Rogers (2018), who revealed that the skepticism of educators frequently becomes a barrier to the implementation of DDI practices, especially when the training and support are minimal.

Another critical issue was the schools' technological infrastructure. Despite the efforts of the teachers to incorporate basic data tools, unevenness in the availability of digital devices and stable internet connections impaired the process. Such constraints are common to underserved schools, according to Chikwe et al. (2024) and Zeeshan (2024), and represent a serious risk to the sustainability of DDI programs. Additionally, data storage and access were not centralized, and this complicated collaboration and tracking over time. Such obstacles underscore the importance of supplementary support systems that do not only provide access to tools but also the professional ability and organizational framework to utilize them successfully.

5.3. Recommendations for Schools & Policymakers

According to the findings, some major recommendations can be given to schools and policymakers who want to enhance mathematics results with the help of DDI. First, professional development must be prioritized. The training programs must not be limited to the initial workshops but also must involve continuous coaching in data literacy, assessment design, and differentiated instruction. In order to integrate data use in daily teaching practice, as Pearson (2014) and Datnow and Hubbard (2015) indicate, it is necessary to support the process over time.

Second, it is important to invest in sustainable and easy-to-use data systems. The schools ought to have available platforms where the performance of students can be stored, accessed, and visualized. Such systems ought to accommodate a wide range of teacher digital fluency and contain in-built support characteristics. According to Learnomics Media (2024) and SchoolAnalytix (2024), scalable analytics resources drive intervention accuracy and timeliness when used wisely.

Third, it is possible to support the culture of collaboration among educators that will have a great effect on DDI. Leadership must establish systems, including weekly data review meetings and peer mentoring, to assist in collective decision-making and ongoing improvement. According to Akosah, Arthur, and Obeng (2025), teacher efficacy and confidence rise when data usage is normalized as a collective process rather than a singular activity.

6. Conclusion

The study examined how data-driven instructional strategies affect math performance in underserved high schools through a mixed-methods case study. The results indicated that DDI had a positive impact on the student performance, with the average math proficiency increasing by 25 percent to 56 percent following its implementation. Some of the most important strategies involved in this improvement included frequent formative assessments, instructional differentiation through student data, and teacher planning. These practices did not only advance academic performance but also increased student engagement and confidence in mathematics. Nonetheless, DDI was successful with some barriers, such as lack of teacher training, poor infrastructure, and initial barriers to change.

The implications for future research are considerable. There is a requirement of longitudinal studies to evaluate the long-term effects of DDI on student achievement, especially when students reach higher levels of academics. The convergence of data-driven pedagogy and culture, digital equity, and teacher well-being should also be investigated further. Extensive comparative research in different geographical and socio-economic settings would assist in establishing the levels of flexibility and scalability of DDI practices across different education systems.

The need to scale DDI in underserved schools necessitates more than the introduction of assessment tools but an integrated approach including policy support, professional development, and a strong technological infrastructure. When executed carefully and fairly, DDI can become a driving force to closing achievement disparities and fostering inclusive excellence in mathematics education. Data-driven teaching is a potential approach that, with specific investment and joint leadership, can become a common practice in underserved learning settings.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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