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Leading STEM Success: The Role of School Principals in Advancing Science and Mathematics Through Instructional Leadership

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Abstract

This study examines the roles and responsibilities of school principals in fostering effective science and mathematics instruction through the lens of Instructional Leadership. Given the critical role of quality education, particularly in science and mathematics, this research aligns with Sustainable Development Goal 4 (SDG 4) on quality education. It explores how school principals create opportunities for effective teaching and learning within their schools. A qualitative case study approach was employed to gain in-depth insights into leadership practices. Data were collected through unstructured interviews with thirteen participants across six Malaysian public schools. This method allowed for a detailed exploration of the ways principals facilitate instructional improvements in science and mathematics. The study reveals that school principals act as instructional leaders, subject specialists, and classroom experts, ensuring accountability for student performance. Their leadership extends beyond administrative duties, directly influencing instructional practices by supporting teachers and implementing structured leadership strategies. This highlights the pivotal role of principals in shaping educational outcomes in science and mathematics. The findings underscore the significance of Instructional Leadership in improving curriculum implementation and teaching quality in science and mathematics. School principals play a crucial role in guiding educators, fostering collaborative learning environments, and enhancing student achievement. Given the multifaceted nature of school leadership, further research is recommended to explore how principals navigate their instructional responsibilities in different educational settings. Understanding these dynamics could inform policy decisions and professional development programs aimed at strengthening Instructional Leadership in diverse school environments.

Keywords: Education quality, Instructional leadership, Professional development, School principals, STEM.

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1. Introduction

The positive impact of strong school leadership on overall school improvement has long been recognized in global education policy and academic research [1]. Effective school leadership is widely acknowledged as a critical factor in shaping student learning outcomes, fostering teacher development, and enhancing the overall educational environment. The ability of school leaders to influence teaching practices, curriculum implementation, and school culture significantly contributes to the success of educational institutions.

This perspective aligns with the argument that weak or ineffective leadership is one of the key factors contributing to school underperformance, particularly in Malaysian public schools [2]. When school leaders fail to provide clear direction, support instructional excellence, or foster a culture of collaboration and accountability, the likelihood of poor student outcomes increases. Leadership shortcomings, including the lack of proper instructional guidance, insufficient teacher support, and ineffective management practices, can contribute to declining academic performance and hinder efforts to achieve school improvement goals.

In this context, the concept of Instructional Leadership plays a crucial role. Research suggests that ineffective instructional leadership may be a contributing factor to the persistent challenges faced by underperforming schools in Malaysia [3]. When school leaders do not actively engage in monitoring and supporting teachers, fail to set clear academic expectations, or do not prioritize curriculum alignment with effective teaching strategies, the result is often a decline in student achievement and overall school effectiveness.

Recognizing the critical role that leadership plays in school success, there has been a growing emphasis on teacher leadership as an essential component of school reform initiatives. Teacher leadership involves empowering educators to take on leadership responsibilities beyond their classroom duties, engaging in curriculum development, instructional mentoring, and decision-making processes that directly impact student learning. Studies have increasingly highlighted the importance of teacher leadership in fostering sustainable school improvement efforts [4].

By integrating teacher leadership into school leadership structures, educational institutions can create a more collaborative and participatory environment where teachers work alongside principals and administrators to implement effective teaching and learning practices. This shift toward shared leadership not only enhances instructional quality but also helps in addressing some of the leadership gaps that contribute to school failure.

Considering these findings, the importance of strong and proactive school leadership cannot be overstated. Schools that prioritize effective instructional leadership and actively support teacher leadership initiatives are more likely to experience improved academic performance, enhanced professional development among teachers, and a more engaging learning environment for students. Therefore, this study contributes to the ongoing discourse on school improvement by examining the role of school principals in advancing science and mathematics education in Malaysian public schools. By understanding how school leaders influence instructional practices, this research aims to offer insights into strategies that can help schools overcome leadership challenges and achieve better educational outcomes.

In recent years, the emphasis has shifted to Instructional Leadership, which enables for diverse perspectives to be heard within the leadership structure and the effective utilization of a school's human resources. Rather of attributing school accomplishments to heroic deeds, Instructional Leadership encourages consideration and recognition of the responsibilities and contributions of all other players [5]. In contrast to traditional conceptions of leadership, which are "*premised on a person controlling hierarchical processes and institutions*," Instructional Leadership is a kind of collective leadership in which teachers gain competence via joint efforts [6]. Individual roles, both official and informal, are major resources for achieving defined goals. Bellibaş et al. [7] assert that Instructional Leadership enables educators to enhance their leadership qualities. As a result, it is critical to acknowledge the work that teachers, school principals, deputy principals, and principals undertake individually and together to improve schools. As a result, this study examined school principals' contributions to the advancement of science and mathematics using an Instructional Leadership paradigm.

It is essential to explore and gain a deeper understanding of the role of school principals within Instructional Leadership frameworks, particularly in relation to how their daily actions influence the development and enhancement of science and mathematics teaching and learning. Gurley et al. [8] describe leadership as the process of identifying, acquiring, distributing, coordinating, and utilizing social, material, and cultural resources to establish conditions that support effective teaching and learning. This perspective reinforces the focus of this study on the pivotal role that school principals play in improving opportunities for science and mathematics education in selected Malaysian public schools.

Furthermore, this argument aligns with Gurley et al. [8], who call for further research that moves beyond traditional school leadership structures to examine leadership as a practice. This perspective, supported by Rigby [9], emphasizes that leadership is not merely about the personal traits or behaviors of individual leaders but about the practical actions that should

be implemented to achieve educational objectives. Similarly, Bickmore and Dowell [10] define leadership as a collective process aimed at achieving shared goals, rather than just the beliefs and actions of a single leader. Consequently, this study focuses on the practical aspects of leadership by analyzing how school principals actively contribute to fostering science and mathematics education in a selection of Malaysian public schools.

In the Malaysian education system, there is increasing evidence that schools apply Instructional Leadership practices with varying degrees of effectiveness. Research by Le Fevre and Robinson [11] highlights the important role of science and mathematics educators, who have traditionally been viewed as followers within the broader school leadership framework. This perspective aligns with Hallinger [12], who argues that greater attention should be given to the responsibilities of school principals as curriculum leaders, rather than focusing solely on the overarching concept of Instructional Leadership.

Given this context, this study raises a critical question: What specific responsibilities do school principals have in promoting and advancing science and mathematics education in selected Malaysian public schools? By addressing this question, the research aims to contribute valuable insights into the leadership practices that support effective science and mathematics instruction, ultimately enhancing student learning outcomes.

2. Literature Review

Given the strong connection between science, mathematics, and employability, as well as the significant role that mathematics plays in various professional fields, ongoing efforts are being made both globally and within Malaysia to improve the quality of mathematics education. Mathematics serves as a foundational subject that influences critical thinking, problem-solving abilities, and workforce readiness, making its effective instruction a priority in educational policy and research. However, in Malaysia, concerns have been raised regarding students' underperformance in mathematics, which has become a pressing issue for educators and policymakers alike. This challenge has led to increased research initiatives and policy interventions aimed at enhancing the teaching and learning of mathematics to ensure that students acquire the necessary skills to succeed in their academic and professional lives [13].

To address these concerns and improve the overall quality of education, Instructional Leadership plays a crucial role in ensuring that school subjects, including mathematics, are taught and learned more effectively. School leaders, particularly principals, are responsible for creating an environment that supports high-quality teaching practices and fosters student achievement. However, as Ismail et al. [14] point out, the relationship between school leadership, administration, and academic performance is not uniform across all schools. Instead, it is influenced by various factors, including the socioeconomic background of the student population. This means that the effectiveness of school leadership in driving academic success may differ depending on the specific challenges and resources available within a given school community.

Furthermore, the evolving landscape of education has placed increasing demands on school leaders. With growing student enrolment, heightened administrative responsibilities, and an expanding workload, principals are finding it necessary to delegate certain leadership functions. In response to these challenges, many school principals are distributing leadership responsibilities to deputy principals and, more significantly, to heads of departments. These department heads play a vital role in directing and overseeing instructional practices within their subject areas, ensuring that teaching methods are aligned with curriculum standards and that students receive the best possible learning experience [15]. By decentralizing leadership and empowering instructional leaders at different levels within the school hierarchy, principals can more effectively manage their institutions while maintaining a strong focus on academic excellence and continuous improvement in teaching and learning.

Delegating critical tasks to school principals is part of the Malaysian educational system's effort to enhance teaching and learning. Thessin [16] believes that if applied properly, this drive has the potential to rewrite a school's performance history. To stress the importance of school principals, Qadach et al. [17] recognized educational supervision and leadership as necessary components for guaranteeing the execution of a high-quality curriculum. As topic specialists, school principals are supposed to oversee and monitor instruction, which includes providing necessary assistance and direction to instructors. By creating positive interpersonal and working connections, School principals are supposed to motivate and serve as role models for instructors [18].

In theory, school principals bear a significant duty for monitoring and supervising instruction, however, this is not always the case in all educational settings. Liu et al. [19] observed that school principals fulfil a variety of responsibilities in their pursuit of efficient curriculum delivery, some of which are apparent in a variety of school situations. Several of these jobs entail making inquisitive judgments, engaging in reflective practice, and engaging in broad-based skilled cooperation. While the actual impact of monitoring instruction is disputed, there is little question that when done effectively, it may have a beneficial effect on student achievement, teacher professional practices, and school atmosphere [20]. This is achievable, however, only when monitoring is utilized to anticipate potential difficulties, to give pertinent counsel and assistance, and not as a punitive mechanism [21].

At their core, school principals play both administrative and instructional leadership roles to support student learning and enhance academic performance in various subjects. These responsibilities are particularly critical in high-achieving schools, where effective leadership contributes to improved educational outcomes. According to Carraway and Young [22], "*based on their experience in Portugal, school principals fulfil three primary functions that are essential to fostering a productive learning environment and ensuring instructional excellence*."

First, principals are responsible for ensuring curriculum integration by fostering collaboration among department members and facilitating partnerships between different departments and other organizational units within the school. This collaborative approach helps to create a cohesive and well-structured academic environment where interdisciplinary

connections strengthen students' learning experiences. By encouraging teamwork among educators, school leaders can promote innovative teaching methods and curriculum alignment that enhance student engagement and comprehension.

Second, principals play a crucial role in coordinating pedagogical strategies and student assessment practices among department members. This responsibility involves guiding teachers in the selection and implementation of effective teaching methods, ensuring that instructional strategies are aligned with educational objectives, and maintaining consistency in assessment procedures. By providing professional development opportunities, mentorship, and structured support, school principals help teachers refine their instructional techniques and adapt their assessment methods to better measure student progress and learning outcomes.

Third, school principals are instrumental in identifying and nurturing department leadership. Recognizing that leadership within academic departments is essential for the overall success of a school, principals work to develop and support department heads who can oversee subject-specific instruction, provide mentorship to fellow teachers, and contribute to the continuous improvement of teaching and learning practices. Strong departmental leadership ensures that teachers have access to the resources, guidance, and support they need to excel in their roles.

In the context of Malaysia, the concept of teacher leadership, rooted in the Instructional Leadership framework, gained significant recognition and traction after 1994. This shift reflected an increasing emphasis on shared leadership within schools, where teachers began taking on leadership roles alongside administrators to enhance instructional quality. The emergence of teacher leadership underscored the growing understanding that effective school leadership is not solely the responsibility of principals but rather a collective effort that involves multiple stakeholders working together to improve student learning outcomes. This approach aligns with global trends in educational leadership, emphasizing collaboration, distributed leadership, and continuous professional development to drive academic success.

Teacher leadership was initially conceived as a strategy to democratize school governance and promote a collaborative approach to educational management. It was introduced as a transformative tool aimed at reshaping Malaysian schools in alignment with the nation's evolving educational policies [23]. The fundamental idea behind teacher leadership was to distribute leadership responsibilities among educators, thereby fostering a shared sense of accountability and encouraging active participation in decision-making processes within schools.

By empowering teachers to take on leadership roles, schools could benefit from a more inclusive and cooperative environment, ultimately enhancing the overall quality of education. However, despite the successes achieved through teacher leadership initiatives, the journey toward fully implementing participatory decision-making in schools has not been without challenges. One of the primary obstacles has been the ongoing struggle over power dynamics within the school structure. Traditionally, school principals have perceived themselves as "*managers, not instructional leaders*" [24]. This mindset has, at times, created resistance to the broader implementation of teacher leadership, as principals were often more focused on administrative duties rather than actively engaging in instructional guidance. The shift toward a more collaborative leadership model requires a fundamental change in perspective, where school leaders recognize the value of shared leadership and instructional oversight as a means of improving student learning outcomes.

Recent research highlights that Instructional Leadership practices are evident in both well-resourced and under-resourced Malaysian public schools, demonstrating that this leadership model is not limited to schools with abundant resources [25]. Instructional Leadership empowers school principals to place greater emphasis on monitoring and supporting teachers in their instructional roles. By assuming a more active role in supervising teaching and learning processes, school principals can ensure that teachers effectively fulfil their responsibilities as instructional leaders within their respective subjects.

Prytula et al. [26] outline several key benefits associated with the consistent monitoring of teachers' instructional practices. These include an improved dissemination of mathematical knowledge, enhanced instructional and lesson-planning skills, and a greater degree of teacher collaboration. Regular monitoring allows school leaders to identify areas for improvement, provide targeted professional development opportunities, and foster an environment where teachers can share best practices with one another.

The discussions presented in previous research indicate that there is still much to be explored and understood about the implementation and impact of Instructional Leadership in schools. As a result, this study contributes to the ongoing discourse by specifically examining the role of school principals in promoting and advancing science and mathematics education within selected Malaysian public schools. By investigating the leadership strategies employed by school principals, this research aims to provide deeper insights into how effective leadership can drive improvements in teaching and learning, ultimately benefiting both educators and students in the Malaysian education system.

3. Theoretical Framework

This article explores Instructional Leadership from a theoretical standpoint, conceptualizing it as a dynamic and interconnected system composed of leaders, followers, and the surrounding context. According to Setwong and Prasertcharoensuk [27] leadership does not inherently exist within any one of these three elements in isolation. Instead, leadership emerges as a process that is enabled when all three components interact and function together. Consequently, rather than focusing solely on individuals in leadership roles, Ali [28] defines Instructional Leadership as a collaborative process that involves leaders, their followers, and the specific environmental conditions in which they operate.

In this study, the distribution of leadership responsibilities is examined through the roles of school principals in science and mathematics education. These principals exert influence within their respective departments, guiding teachers (who function as followers) and working alongside other stakeholders, such as school administrators and educational policymakers. Their primary focus is to foster and enhance the teaching and learning of science and mathematics. By employing this

Instructional Leadership framework, the study investigates the interactions between school principals, teachers, and various stakeholders, as well as the collective efforts made to improve instructional practices in these subject areas.

Despite its recognized importance in educational settings, Instructional Leadership has not yet been fully realized or consistently implemented in many schools. While it has the potential to be practiced informally in diverse educational contexts with significant, though sometimes unquantifiable, effects, its widespread adoption remains a challenge. Considering this, Alam and Ahmad [29] advocates for further research to deepen the understanding of how different Instructional Leadership structures influence the day-to-day functioning of schools. However, the focus should shift away from abstract definitions and theoretical perspectives of Instructional Leadership toward the practical leadership activities that take place within schools. Goldring et al. [30] reinforce this notion by suggesting that the emphasis of Instructional Leadership should be placed on "*conjoint activities*" rather than simply on formal roles or designated positions. Similarly, [31] argue that leadership is a shared and interactive process that emerges through the collaboration of multiple individuals who form a network of distributed knowledge and expertise. At the core of effective Instructional Leadership lies an understanding of what school leaders, particularly principals, do in practice, why they engage in specific actions, and what impact these actions have on school performance and student outcomes [32]. The primary goal of this study is to explore and analyze the ways in which school principals contribute to the overall improvement of their schools.

Successful Instructional Leadership is characterized by the dissemination of clear and actionable information that has tangible effects not only on school staff, including teachers, but also on overall school performance and student achievement. The effectiveness of curriculum implementation is largely dependent on the extent to which school principals actively monitor and guide instructional practices. Research suggests that strong Instructional Leadership can lead to increased teacher motivation and job satisfaction [33]. However, it is important to acknowledge that Instructional Leadership is not a universal solution capable of addressing all the challenges faced by schools [34].

Furthermore, it is essential to recognize that a range of unique and unavoidable factors can influence the effectiveness of school principals in their Instructional Leadership roles. Corbin and Morse [35] note that due to the uneven distribution of power and resources across different educational settings, the intended functions of school principals may be implemented in varying ways, depending on the specific school environment. Roehrig et al. [36] similarly assert that the broader context plays a crucial role in shaping leadership effectiveness and the overall capacity of a school as an organization. However, these considerations do not imply that schools facing socioeconomic challenges are inherently incapable of successfully adopting and applying Instructional Leadership principles. Instead, they highlight the importance of adapting leadership strategies to meet the unique needs and constraints of each educational setting.

4. Method

The objective of this qualitative case study was to explore the phenomenon [37] of the roles that school principals fulfil in fostering and advancing science and mathematics education through the lens of the Instructional Leadership framework. To gain deeper insights into this issue, the study utilized data collected from unstructured interviews conducted in four different high schools. Among these, two schools were in suburban areas, while the other two were situated in township communities, allowing for a diverse perspective on the subject.

While the interviews did not follow a rigidly structured format, the researchers developed open-ended questions inspired by recurring themes identified in existing literature. This approach enabled participants to express their views freely and in detail. Additionally, probing techniques were used to encourage elaboration, ensuring that the collected data consisted of comprehensive, nuanced, and in-depth descriptions provided by the participants [38]. Through this method, the study aimed to uncover valuable insights into how school principals contribute to the effective teaching and learning of science and mathematics.

The suburban schools selected for this study were situated in a community with a relatively strong socioeconomic status in the southern region of Malaysia. In contrast, the two township schools were in economically disadvantaged areas within Kluang and Mersing, where limited resources and socioeconomic challenges may impact educational leadership and learning outcomes. By incorporating schools from lower-income districts, the study was able to provide a broader perspective on the implementation of Instructional Leadership in schools facing additional obstacles, such as limited funding, resource constraints, and socioeconomic barriers [39].

To investigate this issue, the research employed a qualitative case study methodology, which allowed for an in-depth exploration of the phenomenon within its real-world context. Data were collected from six public schools in the southern regions of Kluang and Mersing, as described earlier, to examine how school principals navigate their leadership roles in promoting effective science and mathematics instruction.

Although the findings from this study contribute valuable insights to the existing body of knowledge regarding the role of school principals in enhancing the quality of science and mathematics education, they are context-specific and cannot be broadly generalized to all schools. The unique socioeconomic and regional factors affecting each school must be considered when interpreting the results. Nonetheless, this research provides a foundation for further studies on instructional leadership in diverse educational settings.

Unstructured interviews are particularly effective for gathering detailed insights into complex human experiences, allowing participants to express their thoughts and perspectives freely [40]. This interview format enables researchers to explore nuanced aspects of a subject without being confined to a rigid set of predetermined questions.

In this study, the unstructured interviews were designed to explore key themes related to instructional leadership in science and mathematics education. The discussions were guided by the following focal areas: (1) the monitoring of instructional practices to ensure effective teaching, (2) strategies for enhancing classroom practices in science and

mathematics to improve student learning outcomes, (3) the various forms of support provided to science and mathematics teachers to strengthen their instructional effectiveness, and (4) the specific roles and responsibilities of school principals within the broader Instructional Leadership framework in their respective schools.

To facilitate meaningful discussions and ensure comprehensive data collection, the researchers used probing questions that aligned with these topics. These probes allowed for deeper exploration of the participants' experiences, perspectives, and challenges in implementing instructional leadership. Table 1 provides a summary of the key indicators and essential questions that were utilized to guide the interviews and prompt further elaboration from the respondents.

Table 1.
Summary of interview schedule indicators and key questions.

No.	Indictors	Key Questions
1.	Monitoring instruction	Question 1: What specific processes, strategies, and frameworks are implemented to ensure that teaching and learning in science and mathematics classrooms are effective? How do these measures contribute to improving student comprehension, engagement, and overall academic achievement in these subjects? Question 2: Who is responsible for overseeing and ensuring the effectiveness of teaching and learning in science and mathematics classrooms? What are their specific duties in maintaining high instructional standards? What monitoring tools or assessment methods are used to evaluate teaching quality and student progress? Additionally, what roles do school principals play in supporting and enhancing science and mathematics education within their schools?
2.	Ensuring improved classroom practice in science and mathematics	Question 3: What initiatives, strategies, and programs does the school implement to enhance the teaching and learning of science and mathematics? How do these efforts contribute to improving student engagement, understanding, and overall academic performance in these subjects? Question 4: Who holds the responsibility for improving the quality of science and mathematics education within the school? What are the specific roles and duties of these individuals or groups in ensuring effective teaching and learning? How do they contribute to curriculum development, teacher support, resource allocation, and overall academic success in these subjects?
3.	Providing support for science and mathematics teachers	Question 5: What types of support systems, resources, and professional development opportunities are available to teachers to enhance their effectiveness in teaching science and mathematics? How do these support mechanisms contribute to improving instructional quality and student learning outcomes? Question 6: Which individuals, groups, or organizations are responsible for providing support to science and mathematics teachers? Does this support come from school leadership, colleagues, education departments, or external stakeholders such as government agencies and non-profit organizations? Question 7: How frequently is support provided to science and mathematics teachers? Is the level of support sufficient to meet their instructional needs and challenges? What improvements, if any, could be made to ensure that teachers receive adequate assistance in delivering high-quality education?
4.	The roles of School principals in the broader Instructional Leadership structures of the schools	Question 8: What are the key responsibilities and roles of school principals in overseeing science and mathematics education within their schools? How do they contribute to the effective management and development of these subject areas? Question 9: In what ways do school principals specializing in science and mathematics support and enhance the teaching and learning processes for these subjects? What strategies do they employ to ensure effective instruction and student success? Question 10: How do science and mathematics school principals receive support from various stakeholders within the school community while leading their departments? What forms of assistance, collaboration, or resources do they receive from teachers, administrative staff, parents, and external organizations?

Fifteen participants were given the opportunity to share their narratives, and emerging challenges were identified through specific indicators [41]. These participants, representing four schools referred to as Schools A, B, C, D, E, and F, were invited to take part in the study, provided their consent, and were subsequently interviewed. They were selected based on their involvement in their schools' Instructional Leadership structures for science and mathematics education. Consequently, the selection criteria were well-suited for examining the phenomenon, with the primary focus being on their roles rather than individual characteristics. Table 2 provides an overview of the 15 participants and the criteria used for their selection.

Table 2.
Participant summary and selection criteria

School	Participants	Criteria for selection
A Suburban	• Principal • Mathematics teacher • Physical Science Teacher • Science and Mathematics school principals	• Designated leader and member of the Instructional Leadership team • Subject educator and member of the Instructional Leadership team • Subject educator and member of the Instructional Leadership team • Department head, subject educator, and member of the Instructional Leadership team
B Suburban	• Principal • Mathematics teacher • Physical Science Teacher • Science and Mathematics school principals	• Designated leader and member of the Instructional Leadership framework • Subject instructor and member of the Instructional Leadership framework • Subject instructor and member of the Instructional Leadership framework • Department head, subject instructor, and member of the Instructional Leadership framework
C Township	• Deputy principal • Science and Mathematics school principals	• Positional leader and part of the Instructional Leadership structure • Department leader, subject teacher, and part of the Instructional Leadership structure
D Township	• Principal • Deputy principal • Science and Mathematics school principals	• Designated leader and member of the Instructional Leadership framework • Official leader within the Instructional Leadership framework • Department head, subject instructor, and member of the Instructional Leadership framework

The narratives of the participants were transformed into textual data, which were analyzed using standard qualitative content analysis methods. This process involved reading the text, applying labels through open coding, and organizing the data into emerging categories. Furthermore, these categories were grouped into overarching themes derived from the data [42]. One prominent theme, "*curriculum implementation advice*," emerged due to frequent mentions of the crucial role of school principals in ensuring adherence to curricular policies in science and mathematics education. The unstructured approach to the four subjects in Table 1 facilitated an inductive analysis, leading to the identification of these themes, as previously noted.

5. Findings and Discussions

The results are compiled and explained in this section. The study looked at how school principals may enhance science and math education in a sample of Malaysian government schools. The findings imply that Instructional Leadership supports accountability in the classroom as a means of instruction and learning, as teachers report to school principals, who report in turn to a deputy principal or a principal. The school principals hence, monitor keenly what teachers do and craft strategies that could assist in making them do a better job, as teacher work is a central item in school principals' reports. The findings add to the body of literature that supports that schools take Instructional Leadership strategies, considering human convergence in human capital, effective monitoring, as well as supervision in instruction. The findings identify three central areas: (1) advice on curriculum implementation, (2) monitoring in instruction as well as collaboration, and (3) teacher professional development.

5.1. Study Plan for Effective Management

Implementing the curriculum is a central task of school heads [43] with whom regular liaison is established. The implementation of the classroom curriculum is a litmus test for every educational policy endeavor. The following is a quotation from the math and science school principals at School C on just how central a role is played by school principals in ensuring that the aims of curriculum implementation are achieved:

It is to ensure that the Department's required curriculum is covered and that educators are acquainted with the topics they are teaching, as well as to monitor and assess educators' performance. My duty is to analyze the data and determine where action is necessary. (Head of School, School C)

The interventions aided school principals in recognizing teacher difficulties and giving alternate solutions through the use of a variety of techniques to guarantee the seamless delivery of the curriculum. The Head of School at School B expressed

similar thoughts regarding the importance of interventions to guarantee topic knowledge uniformity, to facilitate lesson delivery, and to enhance classroom procedures. According to the school principal, intervention is,

To ensure that everyone's teaching and learning standards are met, I must ensure that all instructors understand the subject, are capable of disciplining students, and sympathize with students... Standards of learning are critical, and so the entire tale is held to a high level. (School Principal, School B)

Diverse schools initiated a variety of school principals into curriculum applications. The math teacher at School A noted that formal as well as informal measures had been established by the school principals in a bid to monitor each teacher's application of the curriculum. The teacher, however, opined that the monitoring machinery by the school principals focused more on teachers in Grade 12 because these teachers made more revisions in a bid to prepare students for their level of examinations. The math teacher at School A also noted that more monitoring as well as supervision in instruction in Grades 11 and 12 by the school principals enhanced student performance:

If we are teaching Grades 11 and 12, it is a requirement that each day, before we begin teaching this idea, you report to the office to indicate how far along you are with the concept; if we fall behind, the school principals may request that you take more classes. However, this occurs only when we teach Grades 11 and 12. (Teacher of Mathematics, School A)

While school principals are in regular contact with teachers, they are on guard and abreast of what they do or do not do in the classroom. Being knowledgeable is crucial because teachers are independent in classrooms but accountable to the school principals whose intervention makes efficacy a possibility. Because school principals are matter experts, technical competence allows them to decide whether teachers are on track or in deficit and in need of support. Cale et al. [44] as well as Rogan and Grayson [38] both state that whenever school principals oversee as well as direct teachers in a discipline, accountability is in order as well as a possibility of desirable outcomes in teacher quality, classroom methods, as well as student outcomes. In addition, reporting to school principals before lessons ensures accountability [45]. The school principals can hence conveniently decide whether a teacher is away from work and book a substitute. The school principal at School C demonstrated that substitute teachers substituted absentee teachers by scanning the schedules of all available instructors in the discipline to decide whether they are available at that time. Part of a school principal's job involved locating substitute teachers in case a need arises:

I either attend that class or check the schedules—because I always have the timetables for my department's other professors. I will just check to see if any instructors are available during that time, and then we will request a teacher to come in and replace the teacher. (School Principal, School C)

Conversely, in those critical moments in which a substitute teacher with some proficiency in a discipline was not available due to scheduling conflicts, peer teaching was implemented in order that learning did occur. In that situation, another teacher from the same school would enter a classroom to "*baby-sit*" students and keep them on course with material as well as with students. In comparison with a situation study of a situation at School D, in which a lack of activity had its adverse impact, curriculum enactment is made obvious. In School D, a teacher in physical science reported:

Teachers may occasionally be absent from class, and when we enter the classroom and have not done anything, it is a bit tough for them to make sense of the subject matter on their own. (Teacher of physical science at School D).

Furthermore, curriculum implementation in schools was supported by school principals in that they made sure that teachers incorporated technology into classroom activities. Whitley et al. [46] noted that technology is crucial in a time with ongoing advancements in technology, which calls for increased teacher flexibility in the classroom. The School B principal elaborated:

We use laptops and projectors here, so I see to it that everything is intact, ensuring that all learners in a grade get the same work, the same slides which they show [to] the children and their homework that they must do…we send each other emails or even WhatsApp. (School Principal, School B)

These efforts demonstrate how school principals, as instructional leaders in Instructional Leadership structures, contributed to the promotion of opportunities for science and mathematics teaching and learning.

5.2. Supervising Teaching and Fostering Teamwork

Supervising instruction is central in ensuring effective learning and instruction; monitoring is informal or unscheduled classroom visits [47]. The unscheduled classroom visits by school principals made it possible for them to witness instructors in action as well as identify areas that can be supported by them. The school principals were subject matter experts who also worked as instructional leaders in their subjects [48]. The school principal in School C observed that it is important that suitable skills are utilized in monitoring as well as in guiding teachers in achieving subject-based objectives:

If work is not completed, there must be a cause for this. You must ascertain why; what are the obstacles; why was this not accomplished? … If we are meant to be in week 10 according to the syllabus and the instructor is supposed to be in week 8 according to the work schedule – [and] according to the work brochure, the teacher must account for those two weeks. (School Principal, School C)

This is in conformity with the argument that leaders in schools can measure teacher preparation as well as anticipate challenges beforehand through visits in class by monitoring course delivery [49]. Therefore, the room is made for improvement. The target of teamwork in terms of Instructional Leadership is giving leadership roles to teachers, who are usually supposed to have some level of autonomy in classrooms. Peer teacher mentorship is made feasible through a collaborative approach. In addition, the approach leads towards accountability, which directs towards educational success. Accountability ensures that learning as well as teaching is improved. Even though the science school principal at School B was overwhelmed with administrative as well as instructional roles [50] preparations in terms of teacher-teacher visits in class did not fall short.

Each teacher in this system had to be seen by a colleague a total of eight times a year. Teachers have reported high dividends. The approach is in conformity with Shareefa et al. [50]'s concept of Instructional Leadership in the educational context. He pledged that "*attempts at improving education that target increased interactions between instructional unit parts can be more effective*." Johnson [51] hence recommends that visits to classrooms be made as a learning experience for teachers, not as a fault-finding endeavor. Despite no fault-finding intention, some teachers, as in some schools in South Africa, are skeptical and non-cooperative [52].

However, according to a school principal in School C, in case teachers fail in executing work, a firm tone is necessary "*to determine the causes*." The strategy does not question teacher competence or remove autonomy from them. In its stead, it focuses on maintaining accountability that is crucial in effective Instructional Leadership. The learners reported that classroom visits enhanced instruction as well as learning in general because they kept pushing them to meet job demands in order not to be queried by management. Noteworthy is that pressure from visits also influenced instructors in professional development; a sentiment shared by Xie et al. [53]. Teacher output is likely to grow because of increased monitoring as well as supervision by school principals in lesson preparation strategies as well as lesson delivery via visits in schools. In case lesson plans from teachers are not monitored, laxity is likely to creep in, with a negative impact on instruction quality as well as learning [54].

Additionally, when teachers agree and interact, they exchange knowledge and come to a common understanding. Thus, standardization is shown as a feasible method of raising educational standards. School principals have a variety of responsibilities, including fostering collaborative relationships among instructors that aid in the development of their collective knowledge Bryan et al. [55]. Hobbs et al. [56] view this as an indication of successful Instructional Leadership, which is evident in schools that place a premium on educational quality. The Head of Mathematics at School A affirmed this assertion:

I will tell them today that we do this, and we have the same textbook and we have the same lessons. But you are not allowed if you've got Grade twelves to do something with your learners and you don't tell other Grade 12 teachers, you are not allowed to give them examples if you don't present to other teachers, so we work very closely together. (School Principal, School A)

Furthermore, school principals and teachers play a crucial role in resolving classroom issues, such as student misbehavior, by monitoring and supporting education. "*There are several difficulties inside the classrooms, where certain students are misbehaving,*" stated the school principal of School C. Therefore, if they report such students, we must act and then help.

The presumption is that these interventions met school principals demonstrated the presence of accountability at the school, a critical component of Instructional Leadership, and reaffirmed the authority of classroom teachers. Additionally, the school principal of School C explained:

They do not report every case, some things they must be handled as class teachers in class, but they only report cases which they cannot handle in class. For instance, if a learner is continuously late if a learner is continuously not doing their work. They bring such learners to me…I try to find out the reasons why the learners are behaving that way. (School Principal, School C)

These school principals observed that whenever those interventions intended to counteract student misbehavior failed, they involved parents, with much success. Misbehavior on the part of students was frequently triggered by lateness as well as failure to complete work. Similarly, school principals also monitored teachers to determine that those who taught similar grades and subjects communicated effectively. That constituted a form of standardization in the opinion of the science school principal at School B, who observed, "*I look at their assessment work, pre- and post-moderation, and I check that everything is [on a] standard*." The work of a school principal is hence to ensure accountability and that teachers are implementing a stipulated program to achieve the curriculum [57]. In addition, the administrator at School D sketched a pattern of checks and balances that worked towards teacher homogeneity, which could translate into enhanced student performance:

> *They must ascertain whether the instructor is experiencing difficulties and help... to observe the children's work and ensure that the teacher has a positive relationship with the kids and that the teacher-learner interaction in the classroom results in a positive outcome for the learners. The HOD is responsible for assisting instructors and supervising their work. (School Principal, D-Secondary School)*

Headteacher at School C attested that these interventions have a high probability of giving a good guide towards learning and instruction because they enhance coherence as well as consistency in contents through monitoring that is regular monitoring conducted by those who work in similar subjects as well as grades. In addition, School principals also reviewed instructors' files to affirm effectiveness. The deputy at School C clarified that having educators' files empowered School principals with a clearer picture daily on how educators planned a lesson, whether ready as well as effective in a lesson, as well as learners' outcomes, which is intended to be a true picture of effective planning as well as lesson delivery. School principals could be able to determine instructors' success, challenges, as well as assistance that is needed on an individual basis or in a collective basis from that. Li et al. [58] suggest that planning is overseen by School principals because planning is a single obligation with a great impact on learning as well as instruction [59].

Aside from monitoring and supervision of teaching, School principals also served as coordinators between principals, deputy principals, and teachers in a bid to facilitate effective application of the curriculum as well as improve student performance [60]. In turn, whenever some challenges that affect teachers cannot be handled by School principals, they turn to deputy principals in seeking assistance. That is usually a step that is taken once all available means have failed in resolving a situation. The Head of School at School C elaborates that:

We monitor the teachers' work and, when we become aware of any difficulties, we contact the instructor. Then we advise and suggest what may be done. However, if the situation persists, we may contact the deputy principal, as in, this is how far I have gone with this teacher, but we are doing nothing; could you assist? (Head of School, School C)

Additionally, these school principals discussed how teamwork with the administration helps overcome unanticipated obstacles such as teacher absence. He stated that "*if a teacher from your department is absent, you must report to your principal... so that we can locate a substitute*." This method demonstrates that Instructional Leadership does not obviate the need for traditional leadership positions, since they are necessary to supervise the institution's overall performance via specific types of intervention to "*keep the parts together*" [61].

It is important to note that the success in monitoring and guiding schooling at schools by school principals is dependent on their accessibility. In the opinion of the physical science teacher at School B, the open-door approach by the school principal encouraged effective curriculum application: "*We sit with her once a week. her door is always available in case we have some kind of a problem or question. We consult her whenever we have a question. Therefore, she is a guiding figure for us*." The same sentiments about work from the school principal were shared by the teacher in mathematics at School B: "Whatever you are in need of, he is great; he helps us a great deal, and we sit with him on Thursdays in the early morning in order to discuss something, and he is always ready to help us out." Such a perspective supports the roles played by school principals in guiding instruction despite multiple demands on them.

Because school principals are also classroom teachers, they give up a great deal to balance administrative work with classroom load. In response to a question about balancing administrative work with classroom work, the school principals at School C responded that:

Eish, it is difficult, but we strive for balance. In the afternoons, we often perform administrative tasks. It will need some sacrifice. Typically, we as school principals remain here until the school breaks at 14:30 in the afternoon. We often remain till 15:30. True up to 15:30. We give up an hour of our time most of the time to perform administrative tasks. Because there is insufficient time to conduct administrative duties while also teaching. As a result, we try and make a sacrifice of our time. (Head of School, School C)

Hasanah [62] concurs that school principals encounter obstacles, including time restrictions, as they balance administrative responsibilities with teaching responsibilities. They are frequently asked to work overtime and on weekends, which can result in burnout and have a negative impact on the quality of their job.

5.3. Teacher Professional Development

Due to inadequate teacher capacity in high-ranking positions, teacher professional development is a critical instrument in closing gaps that have developed and in making schools effective. Teacher professional development enables teachers to acquire new skills and competence as well as confidence, resulting in effective curriculum enactment [63]. Apart from inducting new teachers into a culture in a school, it enhances student outcomes, motivates teachers, as well as work satisfaction [64]. Successful Instructional Leadership is a norm that makes teacher professional development a key responsibility of a school principal. Schools B and D had school cultures that made it necessary that new teachers be professionally developed by School principals:

Yes, as part of the school's culture, the head of the department...shall be responsible for the orientation of new staff members, various scientific instructors, and via this, we will maintain the science culture in our schools through the younger teachers. We try to develop them properly. (Principal, Secondary School B)

If the teacher is inexperienced, they [School principals] must orient him or her; they must demonstrate what is expected of the instructor and how things work...The School principals are responsible for ensuring the quality of teacher preparation. (Assistant Principal, D School)

While teacher development is not a new tradition in schools in Malaysia, Bacovic et al. [65] point out that it is important that it is conducted in a systematic way to be effective in all contexts in schools as well as according to each teacher's needs in classrooms. The science teacher in School A is also in agreement that teacher development empowers educators because it deals with a variety of subjects as per varied requirements. For instance, training can help in ascertaining which type of question a teacher is weak in as well as in which areas she/he require assistance.

This strategy can be adopted by school leaders to realize latent teacher potential as well as deliver professional development in a bid to aid in maximizing teacher potential. The science teacher at A realized that "*sometimes progress is quite good, which means that they have got the potential but are not giving sufficient time in mastering fundamentals*." In that situation, the professional development strategy will be towards enhancing the classroom pedagogy of the teachers. Hatisaru et al. [66] in a study conducted in Ghana realized that science and math instruction as well as learning, are likely to be improved once teachers have professional development that addresses common challenges.

Additionally, principals also met with teachers on classroom visits in a bid to provide professional development as a response to areas that have been pinpointed. In return, classroom pedagogy as well as student outcomes improved [67]. "*I speak with the teachers, we sit around the table, and I just tell them I saw that you can do better, that you can approach the lesson in that or another manner*," a science school director at School B shared with us.

Correspondingly, in a similar way, the school principals as instructional leaders in the Instructional Leadership format carried out quality ratings as well as evaluated instructors to identify areas that can be developed. Questionnaires that are conducted between classes give feedback that help guide School principals in designing aid that is necessary in schools. Teachers are developed by classroom observations, followed by feedback as well as discussion [68]. In a similar way, as noted by Wu and Huang [69], teacher meetings enable school principals to have direct information that helps guide critical decisions regarding development as well as reform in schools [70].

6. Conclusions

This paper sought to examine the roles played by science and math school principals in enhancing science and math teaching and learning in selected Malaysian government schools, with a focus on Instructional Leadership. The research affirms that science and math school principals' roles in exercising accountability, a central concept in Instructional Leadership, in secondary schools enhanced effective science and math teaching and learning. Some of these findings affirm and/or are in tandem with some material that is reviewed in this research, although within a science and math teaching and learning context. The curriculum implementation, monitoring instruction, teacher cooperation, teacher needs, as well as opportunities in professional development in a bid to promote science and math teaching and learning were some roles exercised by the school principals.

Principals' behaviors also reflected the feeling that teacher autonomy in the classroom is desirable with supervision. Because discipline in those subjects that fall within their domain is a specialist area of school principals, teacher challenges can be pinpointed, and necessary aid can be made accessible through problem-centered professional development activities. Despite time constraints imposed on them by teachers as well as administrative workloads, school principals worked around these challenges to achieve their instructional leadership roles. The extent to which Instructional Leadership is achieved in Malaysian government schools is likely influenced by contextual variables that shape school principals' experiences as instructional leaders. Thus, in this article, more research into the roles played by school principals in varied educational contexts to facilitate science as well as math teaching and learning is proposed. Additional evidence will provide a more complete picture regarding school principals' possibilities and challenges as instructional leaders in the context of Instructional Leadership.

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