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ORIGINAL ARTICLE

Differentiating Pedagogical Leadership Practices Among Formal and Informal Mathematics Teacher Leaders in Bahrain: A PLS-SEM Study

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ABSTRACT

This study highlights the critical role of pedagogical leadership among mathematics teacher leaders in Bahrain, emphasizing the impact of both formal and informal leadership roles. The findings indicate that while both types of leaders demonstrate high levels of pedagogical leadership, there are significant differences in their awareness of leadership practices. This suggests a need for targeted strategies to enhance leadership capabilities across different roles. Utilizing partial least square structural equation modelling (PLS-SEM) with SmartPLS4 software, the study provides robust insights into these dynamics. Key insights include the importance of fostering a collaborative environment through peer review systems and regular team meetings, promoting proactive problem-solving, and encouraging engagement in task accomplishment. Schools should support innovation and autonomy by providing resources and time for experimentation with new teaching methods and technologies. Additionally, addressing the limitations of self-evaluation scales is crucial for accurate assessment of leadership capabilities. Overall, the study advocates for a holistic approach to leadership development, recognizing the unique needs of both formal and informal leaders to enhance educational practices and outcomes.

Keywords: Teacher leadership, Pedagogical leadership, Formal teacher leader, Informal teacher leader, PLS-SEM Analysis.

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INTRODUCTION

Over the past few decades, teacher leadership has been a significant focus of research, with scholars exploring its concepts, theories, influencing factors, and outcomes (Muijs & Harris, 2006; Schott et al., 2020; M. Wang & Ho, 2019; Wenner & Campbell, 2017). Despite this extensive research, there is no universally accepted definition of teacher leadership. Some researchers define teacher leaders as any school leader with a teaching background (York-Barr & Duke, 2004), while others see them as teachers who also hold leadership responsibilities (Spillane & Coldren, 2011; Wenner & Campbell, 2017).

Theories of teacher leadership have evolved significantly. Early studies viewed it from a managerial perspective, influenced by the industrial era (Gumus et al., 2018; Smylie & Denny, 1990). Later, the concept of distributed leadership emerged, positively influencing teacher leadership theory (Heikka & Waniganayake, 2011; Printy & Liu, 2021; Spillane & Coldren, 2011; Spillane et al., 2003). Additionally, transactional and transformational leadership theories have shaped teacher leadership practices (Sayadi, 2016), as has instructional leadership theory, which focuses on teaching and learning (Y. Liu et al., 2021).

One significant shift resulting from these theoretical developments is the change in the roles of teacher leaders. Initially, they were viewed from an administrative and managerial perspective, responsible primarily for administrative tasks (Silva et al., 2000). They were often referred to as heads or chairs of departments (Y. Liu, 2021). However, more recent perspectives view teacher leaders as influencers rather than mere administrators, with roles such as mentors and coaches becoming more common (Antunes & Silva, 2015; B. Smith, 2019). This shift has led to the emergence of both formal and informal roles for teacher leaders.

Teacher leadership has a profound impact on educational leadership. School principals increasingly recognize that they cannot lead alone and need the support of teachers in their leadership practices (Crowther et al., 2009). This is particularly true with the rise of instructional leadership, which focuses on teaching and learning rather than administrative processes. Teachers, being directly involved in teaching, are better equipped to handle this type of leadership (Frost, 2010).

Recent literature has identified various factors that affect the application of teacher leadership. These factors can either facilitate or inhibit the practice of teacher leadership and can be categorized into three main classes: school/administration, colleagues/relationships, and personal factors (Schott et al., 2020; Wenner & Campbell, 2017). For instance, principal support is a crucial school/administration-related factor (Nguyen et al., 2020; M. Wang & Ho, 2019; Wenner & Campbell, 2017). Job satisfaction, influenced by relationships with colleagues, is another important factor (M. Wang & Ho, 2019).

In Bahrain, the situation in public schools mirrors global trends. The Ministry of Education in Bahrain manages four educational regions, each with around fifty governmental schools (Ministry of education, 2019). In these schools, teacher leaders hold various positions, both formal and informal. Formal teacher leaders are typically heads of departments, while informal leaders may serve on committees. A notable issue in Bahraini public schools is the distinction between formal and informal teacher leaders. Formal heads of departments, known as senior teachers, hold official leadership positions and are recognized as leaders in their salary pay slips. Informal heads of departments, known as coordinators, do not hold formal leadership positions but often fulfill leadership responsibilities, especially when there is a shortage of formal heads of departments.

Given the similarities in human behavior (Mishima et al., 2010), the factors affecting teacher leadership

practices globally are likely to affect teacher leaders in Bahrain similarly. Despite the limited studies in Bahrain, it is encouraging to build on the existing literature's recommendations and gaps. This study aims to investigate the formal and informal pedagogical leadership practices of math teacher leaders in Bahraini public schools. The study will explore how these factors impact formal and informal teacher leaders differently.

LITERATURE REVIEW

Teacher Leadership

Teacher leadership is a multifaceted concept explored extensively in educational literature, with scholars offering diverse perspectives and definitions (Schott et al., 2020; M. Wang & Ho, 2019; York-Barr & Duke, 2004). These definitions highlight various roles and responsibilities within educational settings, emphasizing instructional leadership and distributed leadership models (M. Wang & Ho, 2019; York-Barr & Duke, 2004).

York-Barr and Duke (2004) conducted a comprehensive evaluation of literature, defining teacher leadership as the process where teachers influence colleagues, principals, and the school community to enhance teaching and learning practices. Wenner and Campbell (2017) expanded this concept, noting that teacher leaders also assume responsibilities beyond the classroom.

Criswell et al. (2018) proposed a definition emphasizing the need for a profound understanding of educational practices, collaboration to foster innovation, and empowering others to drive sustainable change (Schott et al., 2020). This comprehensive view aligns with the objectives of current investigations into teacher leadership.

Several definitions assert that the main goal of teacher leadership is student development (Childs-Bowen et al., 2000; Smith et al., 2017; Suranna & Moss, 1999; Wasley, 1991; York-Barr & Duke, 2004). Wasley (1991) argued that teacher leaders should engage colleagues in experimenting with instructional practices. Suranna and Moss (1999) described teacher leadership as abilities and qualities shared to benefit students, aiming to increase learning and achievement (York-Barr & Duke, 2004). Smith et al. (2017) highlighted its non-supervisory nature, referring to informal roles of teacher leaders.

Other scholars described teacher leadership as skills demonstrated to improve learning beyond the classroom (Lin et al., 2018). While many definitions view teacher leadership as tools for school change and reform, Wasley (1991) argued its purpose is to ensure the efficiency and effectiveness of the existing system. This study combines these positions, viewing teacher leaders as tools of change and sustainability.

Definitions by Danielson (2006) and Kouzes and Posner (2010) emphasize that teacher leadership transcends formal roles and hierarchical structures. Danielson highlighted its organic nature, Kouzes and Posner asserted it can manifest at various organizational levels.

These perspectives recognize leadership as a dynamic process extending beyond traditional boundaries. Kouzes and Posner emphasized spontaneous leadership driven by initiative, aligning with Danielson's notion of broader organizational impact.

Cultivating teacher leadership requires a supportive environment encouraging autonomy, collaboration, and continuous learning (Cosenza, 2015). Investing in educators' growth and empowerment nurtures a culture of distributed leadership, enabling positive change and collective success. The National Education Association (NEA) emphasizes experience, respect, and collaboration in defining teacher leaders. According to the NEA (2020), teacher leaders are seasoned professionals admired for their expertise and dedication, highlighting the relational aspect of leadership and the

importance of strong working relationships.

Teacher leader

Researchers have explored various aspects of teacher leadership (Wenner & Campbell, 2017). Teacher leaders are generally defined as those who simultaneously teach and hold leadership roles (Katzenmeyer & Moller, 2009; Margolis, 2012; Snell & Swanson, 2000; Wenner & Campbell, 2017). Specifically, those who teach and assume leadership responsibilities are known as hybrid teacher leaders. Margolis (2012) suggests that these leaders should teach K-12 students while also serving in leadership capacities.

Katzenmeyer and Moller (2009) describe teacher leaders as educators who lead both within and beyond the classroom. They should be capable of working effectively with both students and peers (Snell & Swanson, 2000). Similarly, Wenner and Campbell (2017) define teacher leaders as those who continue to teach while taking on leadership roles. They distinguish teacher leaders from other school leaders such as principals, coaches, and vice principals, emphasizing that teacher leaders maintain classroom teaching responsibilities while also leading.

Frost and Harris (2003) argue that teacher leaders can be those who teach and serve on committees simultaneously, practicing leadership without holding formal leadership positions. Other researchers adopt a broader definition, considering any school leader with a formal leadership role as a teacher leader (Smith et al., 2017; Spector, 1997; York-Barr & Duke, 2004). The literature indicates that teacher leaders can be current teachers or those who have previously taught, with teaching experience being a key facilitator for leadership (York-Barr & Duke, 2004). Smith et al. (2017) also view teacher leaders as those in full-time formal leadership positions or those who lead while teaching. Defining teacher leaders as former teachers can lead to inconsistencies, as it would include school principals who were once teachers, making the research on teacher leadership less precise (Wenner & Campbell, 2017).

In summary, teacher leaders can be defined in several ways: those who teach and lead simultaneously (excluding principals, coaches, etc.), those who teach K-12 students and serve as leaders, those who lead within and beyond the classroom, and those who have taught in the past, such as principals. For this study, teacher leaders are defined as those who teach and lead at the same time.

Mathematics teacher leadership

Research on teacher leadership in mathematics highlights a gap in understanding the leadership qualities teachers develop within their communities of practice (Asamoah et al., 2023). Ren and Smith (2018) emphasize that teachers' mathematical knowledge significantly influences their attitudes and beliefs about the subject. Clark et al. (2014) argue that while additional courses can enhance knowledge, they do not necessarily impact beliefs about mathematics. Morales-Maure et al. (2022) suggest that experienced teachers can support others in leadership roles, with personal experiences like race and gender playing a critical role in shaping beliefs about teaching and learning.

Few studies have examined teacher leadership from a disciplinary perspective. Wenner and Campbell (2017) found that only 28% of reviewed studies related to specific disciplines, with just four including math teacher leaders. Berland and Hammer (2012) highlight the importance of disciplinary contexts, noting that different subjects utilize unique resources. Wilson et al. (2014) and Spillane et al. (2003) discuss how leadership structures vary among subjects, with mathematics often led by formal leaders.

Professional development is crucial for enhancing the effectiveness of math teacher leaders. Andre and Andrea (2016) found that training enhances both pedagogical and content knowledge. Meaningful relationships between teacher leaders and colleagues positively impact the adoption of inquiry-based teaching methods. Nickerson et al. (2018) suggest that a teacher's disposition for learning is more crucial for growth than traditional hiring criteria.

Asamoah et al. (2023) highlight the importance of social learning processes, where teachers adopt behaviors modeled by mentors. Nickerson et al. (2018) advocate for seeking teachers with a disposition for learning and ensuring a collaborative learning environment.

The literature, though limited, provides insights into the unique aspects of math teacher leadership. Effective leaders are characterized by deep content knowledge, pedagogical skills, and collaborative dispositions. Professional development and strong relationships are crucial for fostering an inquiry-based approach to teaching. Administrators should prioritize these qualities and recognize the importance of disciplinary contexts when selecting and supporting teacher leaders. This understanding can guide future research and practice, enhancing educational outcomes in mathematics.

Formal and informal teacher leadership

The literature on teacher leadership distinguishes between two main categories: formal and informal roles (Margolis, 2020; Pineda-Báez et al., 2020; York-Barr & Duke, 2004). These roles are essential in the practice of teacher leadership (M. Wang & Ho, 2020b). Liu (2021) compared these roles across 32 countries, highlighting the need for individual studies to gain deeper insights.

Teacher leadership has evolved through three waves: administrative leaders, instructional leaders, and team leaders/change agents (Shah, 2017; Silva et al., 2000). Early literature also supports informal roles, emphasizing teachers' central role in classroom change (Andrew, 1974). Formal teacher leaders hold appointed positions with specific titles and responsibilities, such as department heads or team leaders (Angelle & DeHart, 2016; Harris & Muijs, 2003; M. Wang & Ho, 2020a). Criswell et al. (2018) describe a process where teachers transition from informal to formal leaders by gaining knowledge, developing a vision, and empowering others.

Informal teacher leaders do not hold official positions but influence through their actions and relationships (Angelle & DeHart, 2016; Smith et al., 2017; Wang & Ho, 2020a). They are recognized by their respect among peers and their impact on school culture (Danielson, 2006; Whitaker, 1995). Informal leaders contribute to school development without formal titles (MacBeath, 2012; Smylie & Mayrowetz, 2009).

Principals may have mixed responses to informal leaders, but effective listening and collaboration can harness their potential for positive change (Whitaker, 1995). Liu (2021) distinguishes formal leaders as those with management positions and informal leaders as classroom-based influencers. Fairman and Mackenzie (2015) argue that leadership should be linked to roles, not positions, suggesting that all teachers can be leaders. This study will select informal teacher leaders based on their leadership practices within schools, as detailed in the data collection section.

Pedagogical leadership and teacher leadership

Pedagogical leadership integrates pedagogy and leadership principles to enhance education. Pedagogy involves understanding learning processes and implementing supportive practices (Coughlin & Baird, 2013). When combined with leadership, it focuses on leading effective teaching and learning practices, fostering environments conducive to learning and development for both students and educators.

Teachers exercising pedagogical leadership redefine traditional school roles, emphasizing their centrality in promoting student learning and professional development (Contreras, 2016). This approach advocates for a collaborative, growth-oriented educational setting, focusing on enriching learning experiences rather than merely delivering content. Pedagogical leadership also requires educators to collaborate and continuously develop, fostering traits like curiosity and resilience (Coughlin & Baird, 2013). This creates a school culture prioritizing the learning process, benefiting both students and teachers. Professional development is crucial, with key dimensions including increased knowledge, awareness of

pedagogy quality, developmental skills, and advocacy for early childhood education (Fonsén & Ukkonen-Mikkola, 2019). Effective leadership significantly influences the professional identity of both management and teaching staff, leading to internal improvements within schools (García-Martínez & Tadeu, 2018).

Despite its importance, few teachers see themselves as leaders (Hanuscin et al., 2014). Developing a leadership identity is crucial for teacher leaders, involving more than just knowledge and skills but also a new self-perception (Liu et al., 2021; Zhu et al., 2011). Many teachers are unaware of their potential roles outside the classroom (Katzenmeyer & Moller, 2009), and raising awareness of instructional leadership is essential (Chien, 2020). Factors facilitating teacher leaders' identity include personal priorities, school context, and life experiences (Sinha & Hanuscin, 2017). Social structures and national cultural values also play a role (Angelle & Schmid, 2007; P. Liu et al., 2021). Conversely, dominant school cultures and principals' underestimation of teacher leaders can inhibit leadership identity (Hanuscin et al., 2014; Watt et al., 2010).

Enhancing pedagogical leadership involves reflection, collaboration, and intentional practice. Reflective practices, such as blogging, help cultivate leadership identities (Gul et al., 2022; Hanuscin et al., 2014). Asking reflective questions can inspire intentional practices aligned with educational principles (Coughlin & Baird, 2013). Methodological designs like training programs and seminars also contribute to leadership growth (García-Martínez & Tadeu, 2018).

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METHOD

Research Design

Building on the above, this quantitative study analyzes variable relationships—positive, negative, or nonexistent—to determine their directional associations (Dancey & Reidy, 2011). This study employs variance-based SEM (PLS-SEM) rather than covariance-based SEM for three key reasons. First, PLS is better suited for analyzing models with moderating variables. Second, it is ideal when working with underdeveloped theoretical frameworks or limited prior knowledge of causal relationships. Finally, PLS-SEM prioritizes exploratory analysis over model confirmation, aligning with this study's objectives (Fan et al., 2016; Igolkina & Meshcheryakov, 2020). An additional advantage of PLS-SEM is its robustness in handling non-ideal data conditions. Unlike covariance-based SEM, which relies on maximum likelihood estimation and requires strict assumptions (e.g., large samples, normal distributions), PLS-SEM performs reliably with smaller samples and non-normal data—making it a pragmatically superior choice for this study (Fan et al., 2016). The PLS-SEM approach consists of two main phases: the outer model (measurement model) and the inner model (structural model).

Participants

This study focuses on heads of math departments in Bahrain's public schools as teacher leaders, with 210 such leaders identified across 107 boys' and 103 girls' schools. Heads of departments were chosen for their clear, consistent roles, ensuring reliability and practicality in sampling. The study targets primary, intermediate, and secondary school levels, with a population size of 160 after excluding 50 participants for a pilot study.

Based on Krejcie and Morgan (1970) guidelines, a sample size of 113 teacher leaders is required, representing 71% of the population. Stratified random sampling will be used, with stratification based on academic levels and the distribution of schools across Bahrain's four educational regions. This approach ensures a representative sample and allows for meaningful comparisons between educational levels. The study avoids targeting the entire population to enable advanced statistical analysis using tools like SmartPLS or SPSS and to address logistical challenges in reaching all participants.

Research Instrument

Once the research question is established, selecting the right data instruments is essential to effectively gather information and achieve the study's goals (Punch, 2004). This study employs a scale adapted from Smith (2020) to assess pedagogical leadership from the viewpoints of teacher leaders.

The math teacher leaders' pedagogical leadership scale (PLS) was adapted from Smith (2020), and originally developed to measure social justice issues in teacher leadership. This self-assessment scale was developed through a pragmatic, five-step process—reviewing precedents, creating a prototype, establishing face validity, pilot testing, and final adjustments—to foster leadership development and awareness among teacher leaders. It focuses on actions, situations, and consequences, making it suitable for measuring pedagogical leadership in this study. The scale emphasizes three key domains: leadership identity, awareness of leadership practices, and sharing of expertise. It includes 21 items rated on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), with higher scores indicating greater recognition and application of leadership practices. The scale aligns with pedagogical leadership principles by addressing teacher involvement in decision-making, continuous learning dispositions, and skills supporting adult learning. Example items include statements like "I have clear beliefs about leadership" and "I engage others in planning for change." This tool effectively captures teacher leaders' recognition of their responsibilities and identity as pedagogical leaders.

Data analysis

To interpret the collected data, various statistical methods will be employed. Descriptive analysis will address the first research question, while PLS-SEM using SmartPLS software will be used for the second and third questions. Structural equation modeling (SEM) is a powerful technique for examining multivariate causal relationships, analyzing both direct and indirect effects (Fan et al., 2016). PLS-SEM is particularly suitable when a study uses a moderator for variables or lacks a well-developed theoretical base, emphasizing exploration over confirmation (Fan et al., 2016; Igolkina & Meshcheryakov, 2020). It is also advantageous when sample size and data distribution do not fit common statistical models (Fan et al., 2016). PLS-SEM consists of two phases: the outer model (measurement model) and the inner model (structural model).

The measurement model includes convergent and discriminant validity. Convergent validity ensures items measuring the same latent variable are correlated, tested using factor loading, AVE, and CR (Igolkina & Meshcheryakov, 2020). Discriminant validity ensures items from different latent variables are distinct, tested using cross-loading, the square root of AVE, and HTMT (Rosseel, 2012). The structural model represents the relationships between latent constructs and is similar to a regression test, primarily aiming to test hypotheses. It undergoes quality tests such as R^2, F^2, model fit, and path coefficient (Wang & Rhemtulla, 2021). PLS-SEM is favored for its ability to handle complex causal relationships involving latent variables, offering advantages over traditional techniques like correlations and regressions (Cepeda-Carrion et al., 2019). It is particularly useful for models with numerous constructs and indicators (Sarstedt et al., 2017).

Recent studies highlight PLS-SEM's advantages in certain contexts, allowing for extensive causal modeling and investigation of complex relationships in large datasets (Ali et al., 2018). It is valuable for uncovering nuanced relationships and understanding the complexities of real-world phenomena (Lowry & Gaskin, 2014). After validating the measurement model, the structural model is evaluated, containing relationships between latent variables that confirm or reject the hypothesized model. Essential considerations for assessing structural models include R^2, predictive relevance (Q^2), path coefficients (β), and effect sizes (f^2 and q^2) (Hair et al., 2020; Sarstedt et al., 2017).

The coefficient of determination (R^2) measures the proportion of variance in the dependent variable explained by the independent variables, indicating the model's predictive accuracy (Turney, 2023). Higher R^2 values suggest better model fit, with general guidelines indicating substantial, moderate, and weak explanatory power at 0.75, 0.50, and 0.25, respectively (Sarstedt et al., 2017).

Table 1. Results summary of CFA of Pedagogical Leadership Scale (PLS).

Dimensions	Item	Factor Loading	Cronbach's α	CR > 0.7	AVE > 0.5 and accepted > 0.4	HTMT confidence interval does not include 1
Leadership identity	1	0.677	0.592	0.812	0.463	Yes
	2	0.654				
	3	0.663				
	4	0.717				
	5	0.691				
Awareness of leadership practices	6	0.477	0.701	0.838	0.401	Yes
	7	0.772				
	8	0.766				
	9	0.766				
	10	0.452				
	11	0.555				
	12	0.58				
	13	0.604				
Sharing expertise	14	0.831	0.722	0.911	0.564	Yes
	15	0.784				
	16	0.800				
	17	0.726				
	18	0.665				
	19	0.668				
	20	0.716				
	21	0.799				

FINDINGS

The chapter opens with an analysis of the surveyed data, beginning with the descriptive statistics of the respondents. Following this, the data is prepared for further examination. The study variables are then analyzed for potential correlations using Structural Equation Modeling-Partial Least Squares (SEM-PLS) with smartPLS version 4.0 software. This analysis aims to provide empirical evidence to address the research questions and hypotheses. The findings are presented in descriptive, tabular, and graphical formats to ensure clarity and comprehensibility. Aworanti et al. (2015) suggest that research results should be presented in a manner that enhances reader comprehension and ease of understanding.

The level of pedagogical leadership within math teacher leaders

As previously discussed, the level of pedagogical leadership is examined using descriptive statistical methods, focusing on measures such as mean, median, and standard deviation. This study aimed to evaluate the level of pedagogical leadership among both formal and informal mathematics teacher leaders in Bahrain. The results indicated a consistently high level of pedagogical leadership, with scores of Mean = 4.466 and Median = 4.524. The standard deviation suggests that the responses are dispersed within a range of 3.1 to 4.8.

It is important to note that this outcome may be influenced by the self-evaluation scale used to assess pedagogical leadership. Individuals often rate themselves higher on self-evaluation scales, which is a known limitation of self-reporting studies. Table 4.8 presents the overall results. The standard deviation across the scale is below 1 (SD = 0.560), which could be attributed to the same reason mentioned earlier. A standard deviation close to 1 indicates that the data points are relatively spread out from the mean, suggesting considerable variability or dispersion among the values. This means that while most data points fall within one standard deviation of the mean, there may still be some outliers or extreme values contributing to the overall variability.

Table 2. Descriptive statistics.

Name	Mean	Median	Observed min	Observed max	Standard deviation	Excess kurtosis	Skewness
PLS	4.466	4.524	3.143	5.000	0.560	-0.845	-0.488

Table 2 offers an in-depth comparison of pedagogical leadership between formal and informal teacher leaders. The data reveals that formal teacher leaders have slightly higher mean scores (Mean = 4.483), indicating that they generally exhibit more effective pedagogical leadership compared to informal teacher leaders. This higher mean score suggests that formal leaders are more consistent in applying pedagogical principles and practices.

The standard deviation for informal teacher leaders is notably higher, which points to greater variability in their responses. This variability can be interpreted as a reflection of the diverse experiences and perceptions among informal leaders regarding pedagogical leadership. Informal leaders often operate in less structured environments, which can lead to a wider range of leadership styles and effectiveness. This diversity might stem from the varying degrees of support and recognition they receive from their institutions, as informal roles are not always clearly defined or consistently supported.

Furthermore, the higher variability among informal leaders could also be influenced by their different levels of access to professional development opportunities and resources. Formal leaders typically have more structured pathways for training and development, which can contribute to their higher and more consistent scores. In contrast, informal leaders might rely more on personal initiative and informal networks for their professional growth, leading to a broader spectrum of leadership effectiveness.

In summary, while both formal and informal teacher leaders demonstrate strong pedagogical leadership, formal leaders tend to be more consistent and effective. The greater variability among informal leaders highlights the unique challenges they face, such as less structured roles and varying levels of institutional support. This underscores the importance of providing targeted support and development opportunities for informal leaders to enhance their pedagogical leadership capabilities.

Table 3. Comparison between formal and informal teacher leaders.

		Formal Teacher Leaders	Infromal Teacher Leaders
Pedagogical Leadership (PLS)	Mean	4.483	4.449
	Median	4.381	4.452
	S.D.	0.335	0.395

The moderating effect of formal and informal teacher leadership

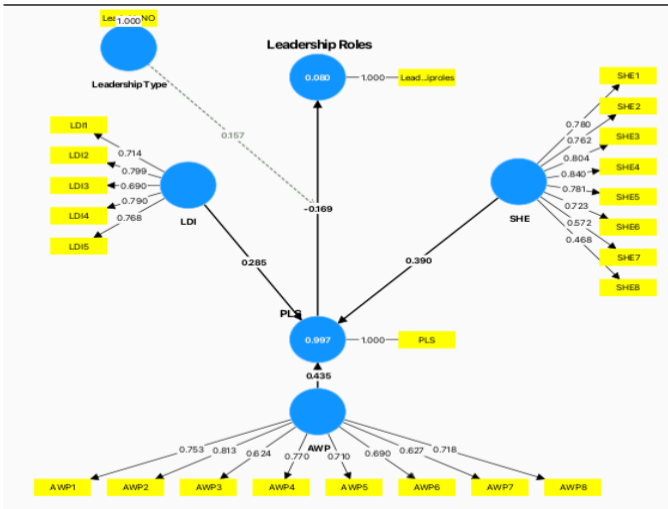
The results depicted in Figure 4.1 provide valuable insights into the differential moderating effects at play. A key finding is that the influence of leadership type as a moderating variable is not consistent across all the variables examined. Specifically, the moderating effect in pedagogical leadership is $\beta = 0.157$. This suggests that while leadership type does affect the relationship between these variables and the leadership roles of mathematics teacher leaders, the degree of its impact varies.

This analysis highlights the complexity of the interactions between leadership roles and various factors such as pedagogical leadership. It underscores the significant role of leadership type in moderating these relationships. The findings indicate that the distinctions between formal and informal leadership roles can substantially influence how these factors interact, thereby shaping the leadership dynamics among mathematics teacher leaders.

Moreover, the differential impact of leadership type suggests that formal and informal leaders may require different strategies and support mechanisms to optimize their effectiveness. Formal leaders, with their structured roles, might benefit from targeted professional development programs that reinforce their established practices. In contrast, informal leaders, who operate in more fluid and less defined roles, might need more flexible and adaptive support systems to harness their diverse experiences and perspectives.

In summary, the results emphasize the importance of considering leadership type when examining the interplay between leadership roles and various influencing factors. By recognizing and addressing the unique needs of both formal and informal leaders, educational institutions can better support their teacher leaders in fostering effective pedagogical leadership.

Figure 1. Moderating effects model and PLS-SEM result.



Note: PLS: Pedagogical leadership; LDI: Leadership identity; AWP: Awareness of leadership practices; SHE: Sharing expertise.

leadership: "sharing expertise," "leadership identity," and "awareness of leadership practices." Among these, "sharing expertise" scored the highest with a Mean of 4.544, followed by "leadership identity" with a Mean of 4.464, and "awareness of leadership practices" with a Mean of 4.389. The close scores across these domains underscore their collective importance in understanding and applying pedagogical leadership among teacher leaders.

Pedagogical leadership is shaped by these domains, each contributing uniquely to its overall framework. "Sharing expertise" involves the dissemination of knowledge and skills among peers, fostering a collaborative learning environment. "Leadership identity" pertains to the self-perception and recognition of one's role as a leader, which is crucial for effective leadership. "Awareness of leadership practices" involves understanding and implementing effective leadership strategies within educational settings.

The study emphasizes the significant impact of the social environment on teacher leaders' awareness of leadership practices. This relationship is influenced by the dynamics of the social setting in which teacher leaders operate. Research by Angelle and Schmid (2007) supports this, highlighting the role of social structures within educational institutions in fostering leadership practices.

Consistent with established literature on organizational culture in schools (Leithwood & Jantzi, 2006), these findings highlight how supportive social environments—characterized by open communication, mutual respect and collaboration—serve as catalysts for developing mathematics teachers' leadership competencies. Where Leithwood and Jantzi found that collaborative cultures improved general teacher leadership, the current study specifically demonstrates their impact on pedagogical leadership capacity in STEM contexts.

Singapore's structured career ladders and innovation incentives offer valuable lessons for strengthening Bahrain's pedagogical leadership development. Singapore's three-tiered career pathway (teaching, leadership, and specialist tracks) provides clear progression routes with dedicated training and reduced teaching loads for leaders (Ministry of Education Singapore, 2023). This contrasts with the study's finding that Bahraini mathematics teachers—especially informal leaders—demonstrate high self-assessed leadership competence but lack awareness of practical leadership strategies. Implementing a hybrid career ladder in Bahrain, combining formal roles (e.g., Lead Mathematics

Teacher) with supported informal leadership opportunities, could address this gap while providing clearer benchmarks for leadership growth (Goodwin et al., 2017).

Singapore's innovation rewards system, including Ministry-funded grants and protected time for experimentation, actively encourages pedagogical risk-taking (Hairon & Tan, 2017). The study identified limited innovation awareness among Bahraini teachers, particularly in collaborative problem-solving and new methodologies. Introducing small-scale innovation grants and peer-recognized awards for STEM teaching innovations could foster a culture of experimentation while mitigating the self-assessment bias noted in your findings (Fullan & Langworthy, 2011). By adapting Singapore's resource-backed approaches to Bahrain's context—particularly in supporting informal leaders—schools could better align teachers' perceived leadership capabilities with actual pedagogical impact.

A key limitation is the reliance on self-reported data, which may inflate leadership scores. Future research should incorporate observational measures to validate findings and explore how power dynamics shape leadership development. Recommendations include structured mentoring to enhance awareness of leadership practices and policy changes to empower informal leaders. By addressing these gaps, schools can cultivate more equitable and effective teacher leadership models, particularly in STEM education contexts like Bahrain. The study aligns with existing literature, emphasizing the pivotal role that informal teacher leaders play in influencing school development, even without formal leadership responsibilities. Many teachers assume informal leadership roles by improving their classroom practices and influencing their colleagues, as highlighted by scholars such as Danielson (2006) and MacBeath (2012). Regardless of formal positions, teacher leaders must influence others to contribute to the school's development, as argued by Cheng and Szeto (2016). Fairman and Mackenzie (2015) advocate for embedding teacher leadership within the professional responsibilities of all teachers rather than associating it with specific individuals or positions.

Conversely, the findings also revealed that sharing expertise scored almost equally between formal and informal teacher leaders, with a slight edge for informal leaders. This suggests that some informal teacher leaders may be more inclined to collaborate and share their expertise with others compared to their formal counterparts. This finding aligns with the notion that effective teacher leadership is not solely determined by formal titles or positions but rather by the actions and roles individuals undertake within the school community (Whitaker, 1995).

CONCLUSION

This study reveals critical insights into pedagogical leadership among Bahraini mathematics teachers when examined through the dual lenses of distributed leadership and professional identity. While both formal and informal teacher leaders self-reported high leadership competence, the gaps in their awareness of practical strategies, particularly in collaborative problem-solving and pedagogical vision, highlight a tension between ascribed leadership roles and authentic leadership identity. These findings suggest that Bahrain's current model may inadvertently reinforce hierarchical structures rather than fostering the collective responsibility central to distributed leadership. The disparity is especially pronounced among informal leaders, whose contributions often go unrecognized in systems prioritizing positional authority over organic leadership development. To address this, professional development must shift from individual skill-building to collaborative identity work—helping teachers internalize leadership as part of their professional identity through structured peer communities.

Practically, this requires rethinking support systems to align with distributed leadership principles. For instance, schools could formalize teacher-led innovation networks where informal leaders co-design professional learning with formal leaders, fostering mutual recognition and shared ownership of pedagogical improvement. Such an approach would

not only mitigate the limitations of self-assessment data (as identified in this study) but also strengthen teachers' professional identity by validating their expertise in practice. By embedding opportunities for distributed pedagogical leadership—such as cross-school lesson study teams or peer-led action research—Bahrain can create ecosystems where leadership emerges from collective practice rather than title alone. This study thus underscores the need to intertwine structural changes (e.g., resource allocation for collaborative time) with identity-focused strategies (e.g., mentoring that affirms leadership agency) to realize the full potential of teacher leaders in mathematics education.

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Ethical approval and informed consent

Informed consent was obtained from all participants involved in this study. Participants were provided with detailed information about the purpose, procedures, potential risks, and benefits of the research. They were assured of the confidentiality of their responses and their right to withdraw from the study at any time without consequence. Written consent was obtained prior to participation, and all data were anonymized to protect participant identities. Ethical board approval was granted by the Research Ethics Clearance Application at the University of Malaysia (reference number UM.TNC2/UMREC_2919).

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request. Due to privacy or ethical restrictions, the data are not publicly available. However, anonymized data may be shared in compliance with applicable regulations and participant consent agreements.

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