MATHEMATICAL IDENTITY, LEADERSHIP, AND PROFESSIONAL DEVELOPMENT: HIDDEN INFLUENCES THAT AFFECT MATHEMATICAL PRACTICES

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The New Zealand Government recently introduced National Standards in response to concerns about levels of student achievement in mathematics and literacy, and significant investment has been made in the *Numeracy Development Project*. Principals are responsible for improving teacher practice but most principals were educated in contrasting pedagogies to that of the NDP and have more language arts than mathematics strength. This qualitative case study compared two diverse, primary-sector principals, chosen for contrasting mathematical backgrounds and leadership of mathematical professional development. The results illustrate that a school principal is an influential 'cog' in the mathematics professional development process and that their direct participation in mathematics professional development is required for effective leadership of mathematics. It provides evidence about the mediating influence of leadership in mathematics professional development and learning in schools. Practical implications for improving classroom practice in a distributive leadership environment will be discussed.

Introduction

Principals of primary sector schools are less involved in professional development for mathematics than other subject areas. Many current principals did not learn school mathematics through a constructivist pedagogy and many may not have taught in a classroom using constructivism. Spillane (2005) unmasked substantial differences between subject areas in terms of leadership. In mathematics-related leadership routines, fewer leaders were involved and they rarely contributed, whereas direct principal involvement was more prevalent in literacy routines. Timperley, Wilson, Barrer and Fung (2007), in their meta-analysis of research on teacher professional learning and development, highlighted a lower profile for school leaders in professional development in mathematics than in any other curriculum area, "It may be that what was being asked was as challenging for leaders as for the participating teachers" (p. 75). To compound the problem, Nelson and Sassi (2005) state that the knowledge that principals hold, in terms of mathematics education, will be reflected in how they approach the mathematical content and pedagogical improvement needs of their staff.

This paper explores how principals identify effective classroom practice and professional development needs if their own mathematical identity, knowledge, and presence are weak.

Background

The role of the school leader

In the past 20 years, schools have changed in terms of governance and management (e.g., New Zealand's Tomorrow's Schools) and subsequent changes in leadership have been necessary. The move requires school leaders to empower others whilst staying in touch with 'best' practices and assisting staff in working towards improvement in professional practice. Many writers support the concept of distributive leadership (e.g., Leithwood, Harris & Hopkins, 2008), and principals have been encouraged to embrace this paradigm as a means of sharing the demands of the heavy workload imposed by self-management. The core of building pedagogical capacity in schools lies in how the principal focuses on the development of teachers' knowledge and skills (Fullan, 2002). According to Robinson, Hohepa, and Lloyd, (2009), the leadership dimension that produces the largest effect size on student achievement is where the school leader is participating in, and promoting, formal and informal opportunities for teacher learning and development as leaders or as learners, or both. Extending current knowledge *in mathematics* is important in light of the dramatic changes effected from cognitive psychology and mathematics education research. Spillane (2000) asks if it is reasonable to expect leaders "to develop rich conceptions of mathematics" (p. 169) and concludes that it is reasonable because of their role in selecting and organising professional development for teachers.

A key element in educational leadership is for principals to intentionally enter classrooms to gather information and support teachers on an ongoing basis (Williams, 1996). Classroom visits should be designed specifically to assess the degree of professional development implementation. Fink and Resnick (2001) identify that effective principals "are in teachers' classrooms every day" (p. 606).

The leader-middle management-teaching team relationship

When shared leadership is incorporated over an existing hierarchical structure it may lead to challenges when viewed from the perspective of Anderson's (2004) 'model of leadership reciprocity'. Anderson describes three situations: the 'contested model', the 'buffered model', and the 'interactive model'.

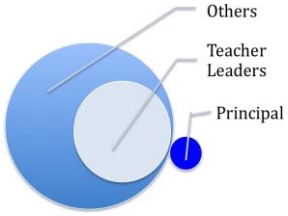

Figure 1. Contested Model

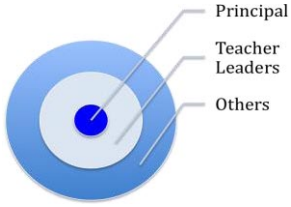

Figure 2. Buffered Model

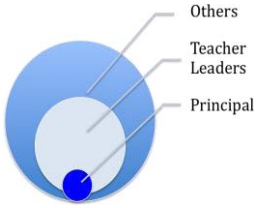

Figure 3. Interactive Model

In the "Contested model', shown in Figure 1, the principal stands 'out of the loop' usually in formal leadership roles and perhaps in opposition to teacher leaders. Figure 2 shows the 'Buffered model', where access to, and influence upon, others is mediated through the teacher leaders. The final of the three models, shown in Figure 3, is the 'Interactive model' where the principal, teacher leaders, and other members of the school community share accessibility equally and communicate freely.

Mathematical Identity of teachers and principals

Grootenboer and Zevenbergen (2008) define identity as "how individuals know and name themselves … and how an individual is recognised and looked upon by others" (p. 243). The cultural or psychological interactions that affect a person's method of relating to mathematics are termed 'mathematical identity'. According to Grootenboer and Zevenbergen, the teacher's role is to facilitate the development of students' mathematical identities by bridging students and subject, enabling a positive relationship with mathematics. A negative aspect of mathematical identity is mathematics anxiety, and Hembree (1990) showed that pre-service primary teachers had higher levels of mathematics anxiety than any other major on US university campuses, whilst it is estimated that more than half of all Australian primary teachers have negative feelings about mathematics (Carroll, 2005). Weak teacher mathematical identities must be addressed through appropriate leadership and sustained professional development.

Effective professional development in mathematics

Research suggests that content, rather than context, of learning is the most influential factor in determining whether professional development in mathematics will result in improved student achievement (Timperley et al., 2007). Professional development of 14 hours or less showed no effect on teachers' learning. The largest effect involved programs offering 30 to 100 hours spread out over 6 to 12 months (Darling-Hammond & Richardson, 2009). Research shows that there is a link between improving mathematical identity and engagement with professional development activities (e.g., Millett, Brown, & Askew, 2007). Higgins and Parsons (2009) characterise professional development that encourages change in mathematics instructional practice as having a focus on subject matter knowledge, an understanding of how students learn the subject matter, and how to convey content in meaningful ways.

Data collection and analysis

This paper reports a case study of two New Zealand primary schools; referred to as School A and School B with the respective principals referred to as Principal A and Principal B. It examined the principals' mathematical identities and leadership, the teachers' mathematical identities, and the professional development offered in mathematics pedagogy. The two schools were selected because they showed clearly contrasting mathematical histories of their principals, different approaches to professional development, and different outcomes on the mathematical identities of the teachers. Both schools had similar student ethnic compositions and socio-economic locations. Around 60% of the total teaching staff of each school responded to the survey and volunteers were then interviewed in a semi-structured format.

A qualitative approach was selected as the most appropriate method of obtaining data. A survey design was supplemented by interviews to explore primary principals' and teachers' perceptions of the provision of mathematics professional development in view of the inherent mathematical identities and the surrounding issues. The survey included an adapted Mathematics Value Inventory, or MVI, (Luttrell et al., 2010) whereby questions were posed about attitudes towards mathematics and responses made on a five-point scale ranging from strongly disagree to strongly agree. The statements

included indicators of either negative or positive beliefs about the value of mathematics. The data were analysed by the researcher using a grounded approach of identifying codes, categories, and themes that were then used in conjunction with dialogue and quotes from participants.

Findings

The principals' and teachers' mathematical identities

Principal A did not formally study mathematics beyond secondary school nor completed any further qualification that included a mathematics or mathematics education component. Principal A described a history as a mathematics student and reflected negatively on their learning experiences in mathematics, "I am one of those kids who didn't get it at school and I know what that feels like." Principal A did not connect to mathematics as a school student because, in a psychological sense, the education received failed to relationally bridge student and subject as described by Grootenboer and Zevenbergen (2008). A teacher education programme started to change the perception of their mathematical identity by changing elements of identity (such as a new path for their life history and improved affective qualities and cognitive dimensions for mathematics). Using the Mathematics Value Inventory (MVI), Principal A showed that they currently hold positive feelings towards mathematics. The repaired mathematical identity, combined with negative childhood memories, gave Principal A an increased understanding into students who struggle to understand mathematical concepts, "I can say to the staff that it's not that they are not trying: they don't get it." The MVI showed that 90% of teacher respondents at School A held positive feelings towards mathematics despite prior mathematics anxiety for some participants. A teacher explained, "I was actually frightened at the thought of learning maths well enough to teach it. Coming here and getting the training has only made me more enthusiastic for maths."

Principal B had formally studied Level 1 mathematics as a university undergraduate for a non-mathematical degree, with no further qualifications that included mathematics or had a mathematics education component. Principal B had a strong mathematical identity as a school student and as an adult. They held mathematics to have a high value and recognised the importance of mathematics as a subject area and as a life skill. Principal B had not taken part in Numeracy Project professional development because, the Principal stated, "we couldn't see the need". Up to 44% of teacher responses at School B showed negative feelings and an explicit lack of value held for mathematics.

Professional development related to mathematics

At interview, evidence was provided that Principal A consulted with and considered the needs of individual teachers, pedagogical practices were observed and weaknesses identified, student achievement data was noted, and governmental initiatives were taken into account before goals for professional development were established. The school focus on mathematics (often with external facilitators) was reflected whereby 100% of teacher respondents had undertaken mathematical professional development in school. All newly employed teachers received an intensive introduction to the Numeracy Project and then joined the whole school professional development programme.

School B's professional development programme was in direct contrast to School A's. Only 8% of teachers at School B had undertaken mathematics professional development. Literacy was the most common curriculum for professional development followed by ICT, inquiry, and English as a second or other language (ESOL). Mathematics and music professional development followed these subjects and science and Physical Education tied for last place. Teachers from School B stated that the school participated in too many initiatives and this resulted in a lack of focus for professional development programmes. They voiced concern at the apparent lack of links to best practice and classroom visits. Despite the teachers in School B, overall, holding higher mathematics qualifications than those held by the teachers in School A, they indicated a lack of content knowledge. "There are teachers at our school who don't know higher than 3A. How are we catering to those top kids when the teachers don't know it?" School B's teachers described the professional development in mathematics offered in the school as inadequate to meet their needs. One teacher stated, "I can't even remember doing maths PD. I don't think we are helping people that don't have strength in maths enough."

The principals' promotion of, and participation in, professional development in mathematics

Principal A was a consistent participant in mathematical professional development through personal attendance at professional development activities, working alongside the mathematics curriculum team, and in staff meetings where mathematics professional development was provided. Ninety percent of School A's teachers believed that Principal A promoted access to mathematics professional development well or better.

Almost half of School B's teachers recorded that the principal never participated in professional development in mathematics whilst 42% stated that this occurred once each year or less. Teachers outlined how they considered that Principal B's participation was inadequate in professional development and staff meetings. Thirty-one percent of School B teachers responded that they needed more professional development to maintain their skill and 46% said they did not receive any mathematics professional development at all.

The principals' leadership of mathematics

Principal A described their leadership of mathematics as distributive, adding "We have a maths team of teachers. I am involved in the team and decision-making and in setting a budget that will allow for the gains made to be sustained." Principal A assumed an interactive role of leadership reciprocity (Anderson, 2005) through attendance at the meetings and direct involvement in the professional development. Principal A merged internal professional development with external opportunities, including the provision of externally facilitated workshops twice each term. Resources were provided to allow attendance at these workshops and the principal managed the resources. Curriculum team meetings focused on how best to implement new learning and recommended the resources required. The principal attended these meetings. Staff received information through regular staff meetings where the curriculum team shared learning opportunities.

Principal B also espoused their preferred style of leadership as distributive, but not all School B teachers saw Principal B's version of shared leadership as being ideal, especially in mathematics. The teachers outlined how they felt that the leadership team

no longer led curriculum. One teacher said, “The whole curriculum focus has been lost from a senior management point of view”. Yet Principal B acknowledged that principals “need to engage in learning with the person to whom it is delegated so that you have a shared understanding.” However, Principal B also outlined a view that principals need not understand the content of mathematics: “I don't think a principal has to be mathematically orientated but has to understand that mathematics is one of the foundation skills”.

Discussion and conclusion

Mathematical identity of principals

Common sense might suggest that a principal with a strong mathematical identity would identify more strongly with the subject and focus more on the provision of professional development specific to mathematics. My research found a stronger relationship between a formerly weak mathematical identity that had been addressed and the promotion of, and participation in, mathematical professional development than between a strong but unaddressed mathematical identity and promotion of, and participation in, mathematics professional development.

Principal A’s position on the Mathematics Value Inventory (Luttrell et al., 2010) indicated that they had successfully repaired their mathematical identity and they have shown enthusiasm for professional development in mathematics content and pedagogy. This created a clear purpose for mathematics leadership, simply described by Principal A as being that a child in their care “would not suffer a belief that they were mathematically useless”. In contrast, Principal B described having a lifelong comfort with mathematics, indicating a positive mathematical identity from an early age, and having studied mathematics content at university. The MVI scale indicated that Principal B held mathematics to have a high value despite a lack of professional development in the subject and a fading knowledge base.

The mathematical identity of teachers

Teachers at School A benefited from stronger mathematical identities than teachers at School B. Only 10% of School A teachers indicated any negative feelings towards mathematics on some statements, contrasting sharply with School B’s teachers where 28% indicated negative feelings towards mathematics.

Those with a weak mathematical identity at School A started to address that identity immediately upon joining the school. Teachers stated that the focused approach gave them stronger content and pedagogical knowledge. That the entire school participated in mathematics professional development encouraged sharing and reflection, identified by Alton-Lee (2003) as a vital ingredient in effective professional development, and this strengthened their mathematical identity. In contrast, School B teachers had less developed mathematical identities and demonstrated having more negative feelings for mathematics. Some School B teachers lacked confidence in teaching mathematics and some perceived that they did not have the content knowledge required to teach at the level expected of senior primary students. In spite of this, a need for teachers to participate in mathematics professional development was not identified. The lack of targeted professional development opportunities in School B indicated that the mathematical identities of School B’s teachers were being neglected.

Educational leadership of mathematics in practice

Principal A promoted, and participated in, professional development in mathematics, and conducted classroom visits to evaluate mathematical teaching practice. This task had priority over other administrative demands. It appeared that Principal B set other priorities above attending staff meetings for professional development in mathematics and did not do classroom visits for the purpose of evaluating the teaching and learning of mathematics. By not participating in professional development in mathematics, Principal B was not involved at a level where they could influence classroom practice or objectively identify teacher and student needs. Principal B reflected Spillane's (2005) findings of a lower leadership profile and different leadership routines applied to mathematics when compared to other curriculum areas.

Distributive leadership of mathematics in the case study schools

Both principals demonstrated contrasting positions on Anderson's Model of Leadership Reciprocity (2004). Principal A was firmly positioned within the Interactive model. Accessibility between the Principal, the lead teacher of mathematics, and other teachers was shared equally and communication between the constituent members was free flowing. In addition to highly visible participation in mathematical professional development, Principal A reinforced the role of educational leader in mathematics by promoting staff access to mathematical professional development and providing the necessary resourcing to ensure that access. Principal B was positioned in Anderson's Buffered model. Principal B stated that they did provide the resources to enable professional development, but the absence of direction towards mathematics and a lack of participation in mathematics professional development meant that the support was without structure or priority. Statements made by the teachers indicated a declining participation by the principal in mathematics professional development or no participation at all. By not interacting with the wider teaching body in a reciprocal manner, Principal B was considered to be more concerned with the study of pedagogical improvement rather than the practices that would lead to the improvement itself.

Principal participation in professional development

Nelson and Sassi (2005) raise the question of how much and what kind of knowledge is sufficient in order for principals to be able to make effective decisions regarding instruction. Principals who have not undertaken ongoing professional development in mathematics may not recognise, nor provide for, excellence in mathematics teaching and learning. Principal A improved both their own knowledge and their influence on teacher practices by sharing in the learning about mathematics alongside the teaching staff and being available for regular discussions with staff on mathematics. Nelson and Sassi tell us that the nature of a principal's mathematics knowledge affects their appreciation of mathematics instruction, and it was apparent that Principal A was well enough informed to have been able to make decisions regarding instruction.

From Principal B's perspective, they 'shared' the leadership. However, it was clear that the teachers did not see the principal as the leader or as a member of a leadership team for mathematics. It was also apparent that the teachers had undertaken little mathematical professional development. The lack of professional development activities offered in mathematics and the absence of classroom visits and discourse about

mathematics are evidence that Principal B's hands-off approach to mathematics led to a limited appreciation of how and when to help initiate change in mathematics. Identification of the 'expected outcome – observed implementation' gap of professional development is critical for a principal if resources are going to be effectively targeted. Principal B was not in a position to measure the gap. As such, there was no awareness of the need to address the weak mathematical identities of the teachers at School B.

Principal B's lack of strategic approach to professional development was shown in the wide and discrepant range of professional development activities undertaken. School B's professional development was done with the intent of providing personalised professional development for each teacher but the identification of pedagogical needs was made by the individual teacher themselves and not on data or observation. Therefore, if the teacher's mathematical identity was so low that this cognitive effect turned into a behavioural response of avoidance of participation in mathematical professional development, as described by Richardson and Suinn (1972), then there was no mechanism to ensure that students were achieving a good mathematical education.

School A's ongoing concentration of professional development towards mathematics ensured that the teachers at School A complied with Darling-Hammond and Richardson's (2009) research that the largest effects come from programs offering 30 to 100 hours spread out over 6 to 12 months. Alternatively, School B's 'smorgasbord' approach to professional development meant that each teacher received less than 14 hours of mathematics professional development, the level at which Darling-Hammond and Richardson stated that there would be no effect on teacher learning.

The influence of the principal on the mathematical identity of teachers

Principal A positively influenced the mathematical identity of their teachers through the promotion of a formally structured, long-term mathematics professional development plan based on the Numeracy Project. The Principal's direct involvement, where they asked questions to deepen their own understanding and encourage others to seek clarification, demonstrated to the teachers that a mathematical identity may be improved by critical evaluation and reflection. The teachers from School B expressed concern that there was no educational leadership of mathematics and that there was a lack of professional development offered to improve their ability. The mathematical identity of teachers at School B suffered and they exhibited lower value perceptions of mathematics and higher mathematical anxiety than the teachers at School A.

Implications

As primary sector teachers have a higher anxiety towards mathematics than any other curriculum area, addressing the teachers' mathematical identity through sustained professional development should be a priority in all primary schools. It is the responsibility of the principal to attend to quality professional development, and to interact in the design process, if consistently high quality mathematical practice is to be attained within their schools. This will only be achieved through taking an interactive position in leadership reciprocity and not by arm's-length management of resource provision. Principals need to be aware that they need personal professional development in order to attend to their mathematical identity and to make decisions concerning effective practice in mathematics teaching and learning. Principals need to understand

the benefits of 'standing alongside' their teachers as they undertake professional development in mathematics; learning the same content at the same rate as the teachers. Principals should reflect on the difference between distributive leadership and exclusion of themselves from areas in which they should be involved and informed. They may also gain information to identify where capacity lies or is absent in mathematics.

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