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Leading and Supporting Mathematics Teacher Change: The Case of Teaching and Learning Coaches

Leonie Anstey
Department of Education and Early Childhood Development

Barbara Clarke
Monash University

There is growing interest in the use of coaching to lead and support teacher learning in mathematics. Current initiatives include a large scale systemic initiative in Victoria – Teaching and Learning Coaches Initiative (TaLC). The purpose and intention is to provide intensive assistance to identified schools to bring about change in classroom practices that are necessary to improve student outcomes and build teacher capabilities. In this paper, the literature on coaching is discussed and research findings presented from a study involving fifteen coaches from regional Victoria.

In 2007, the Victorian Department of Education and Early Childhood Development (DEECD) worked extensively with Professor Richard Elmore on evaluating the School Improvement Practices in Victorian Government schools. Elmore (2007) noted that "Human Investment" was the strength of the Education System in Victoria, and suggested that teachers

> should be given opportunities to develop a cosmopolitan view of their practice, one in which new and powerful ideas about teaching practice are public goods, rather than private practice. They should be exposed to coaching and mentoring others as early as possible in their careers. (p. 7)

The Teaching and Learning Coaches Initiative (TaLC) was established in 2008 and intended to provide assistance to schools to improve student outcomes in mathematics and, in the case of a small number of schools, in science. The initiative is underpinned by the key findings that student achievement is determined to a significant extent by the knowledge and skills of teachers in individual classrooms (Darling-Hammond, 2000; Wenglinsky, 2000). In particular, the focus was on teacher capacity to establish priorities, analyse student results, measure student progress and improve the quality of learning and teaching. This represented a change in focus for School Improvement policy to more direct support of teachers in the classroom and accountability of each of the regions.

Coaching as a form of professional learning appears to be increasingly used by school systems. In Victoria, both the Catholic and Government systems have large scale coaching initiatives. In both these contexts it is used to support underperforming schools with the intent of improving student performance. Similar trends have been evident in the United States where the initiatives are often poorly planned and implemented (West, Hanlon, Tam, & Novelo, 2007). There is evidence of the significant impact of teacher quality on increased student achievement (Hattie, 2003) and content coaching in the form of experienced and

knowledgeable support seems to provide an argument for enabling change and improvement in teaching practice. McCombs and Marsh (2009) in the context of reading coaches comment that:

> as on-site personnel who interact with teachers in their own workplaces, coaches should theoretically be able to facilitate learning that is context-embedded, site-specific, and sensitive to teachers' actual work experiences. (p 12)

The popularisation of coaching as a professional learning model has resulted in an increase in publications of manuals for coaches in mathematics (e.g., Hansen, 2009; Hull, Balka, & Miles, 2009).

There are a range of models for coaching and mentoring of teachers. One way of categorising these is into two main categories: peer coaching which involves mutual consultation between teachers of equal status; and teacher mentoring which involves a hierarchical relationship (Murray, Ma, & Mazur, 2009). Peer coaching tends more towards a partnership model that is internal to the setting. There have been inconsistent findings on the success of this model (Bruce & Ross, 2008; Murray et al., 2009). Murray et al. concluded that the ambiguity of roles in peer coaching and the lack of the coach as leader are problematic. Teacher mentoring can be thought of in two ways, the more traditional mentoring of pre-service or beginning teachers that is an essential component of induction into the teaching profession, and also coaching for professional learning for practising teachers. This is closest to the model that is being articulated in the current Victorian systemic initiatives where an externally appointed "expert teacher" is provided to a school or teacher. They work within the school on problems of practice directly related to the targeted teachers. There are parallels to the model of the sporting coach.

The reference paper on which the DEECD initiative is based (Boyd, 2007) proposed that coaches would work with individual teachers in their classrooms in a *peer coaching* role:

> By building a relationship with their coachee through discussion and observation of their classroom practices they will work collaboratively with their coachee to set goals for what the teacher coachee wants to accomplish during the time that they will be working together. (p. 7)

> The coaches will determine teachers' learning needs and how to meet those needs by targeting conversations around instruction, raising questions, organizing professional development opportunities, bringing in research and articles, and guiding teachers in developing new practices. (p. 10)

The model as previously described is clearly hierarchical with the coaches in a position of power, and not peer coaching as defined by Murray et al. (2009). The advice above is of the form of guidelines for developing a supporting relationship while leading the improvement. There is also a specific focus on developing a more collaborative professional culture with the schools where the coaches are working.

> The TaLC initiative aims to support a culture in schools where classroom observations, ongoing professional conversations and reflection on what makes good learning and teaching become a regular and valued part of the school day. These steps can contribute to the creation of a collaborative work culture and learning community across the whole school. (p. 13).

Increasingly, coaches are being characterised as leaders (Guiney, 2001). We would support this characterisation and believe that the analysis of literature below as well as the research results presented suggests a role that is leading and supporting teachers through the process of change and improvement. The effectiveness of coaching to achieve the ambitious gains in student achievement that are often articulated in policy documents is still an open question that requires further research and examination, but we want to explore the role of coaches through the early implementation of the Victorian TaLC initiative.

Some Background Literature

It is argued that coaching has the potential to have a high impact on classroom practice. Feger, Woleck, and Hickman (2004) found that:

- effective coaching encourages collaborative, reflective practice;
- effective embedded professional learning promotes positive cultural change;
- a focus on content encourages the use of data analysis to inform practice;
- coaching promotes the implementation of learning and reciprocal accountability; and
- coaching supports collective, interconnected leadership across a school. (pp. 2-5)

The first aspect for consideration is the skills and knowledge required of a coach. Generally, the literature on this aspect of coaching is general educational rather than specifically mathematics.

Skills and Knowledge of Coaches

A review of relevant literature suggests the following skills and understandings are required to enable the implementation of the role of the coach:

- the ability to read, analysis and act upon a range of student data sources including state/national tests, local student achievement data, formative and summative assessment (Boudett, City, & Murname, 2005);
- a deep understanding of the content area in which they are working (Feger, Woleck, & Hickman, 2004);
- sound pedagogical practices that enable them to discuss instructional practices and models for explicit teaching and learning. (DEECD, 2006);
- the ability to model/demonstrate effective lessons to broaden teacher understanding of student learning (Feger, Woleck, & Hickman, 2004);

- the ability to identify and plan for change through focused inquiry to broaden the platform for work with teachers (Burkins, 2007); and
- the flexibility to adapt their methods to be aligned with the goals of the school/teacher/and educational system (Feger, Woleck, & Hickman, 2004).

Steiner and Kowal (2007) present three broad categories of skills that an effective coach should possess: pedagogical knowledge, content expertise and interpersonal skills. Teachers in primary schools require a deep understanding of mathematics for teaching and this is a key component in improving student learning outcomes (Hill, Rowan, & Ball, 2005). Shulman (1986) discussed the combination of content and pedagogical content knowledge for teaching.

> Mere content knowledge is likely to be as useless pedagogically as content-free skill. But to blend properly the two aspects of a teacher's capacities requires that we pay as much attention to the content aspects of teaching as we have recently devoted to the elements of teaching process. (p. 6)

If, as widely accepted, teachers of mathematics require appropriate strength in both content and pedagogical content knowledge, what is the nature and extent of knowledge and skills required by *mathematics coaches* as they work with experienced and inexperienced teachers? Much of the coaching literature is general, focusing on leadership and relational aspects, with an implicit assumption that the pedagogical content and content knowledge and skills of coaches will be sufficient for the role. We will discuss this further through the results of the research into the implementation of the DEECD TaLC initiative.

Change Coaching

The basis of the role of the coach is to effect change. If coaches hold inaccurate views about change, it can lead to ineffective, frustrated and potentially harmful educational outcomes (Toll, 2004). The challenge of change are well documented and phases such as "change takes time," and "it is painful to change" can often been heard and quoted (Toll, 2004).

Toll (2004) presents six different perspectives that can be applied to coaching for change. There are coaching focused on behaviour, attitude, cognition, inquiry system and culture.

Coaching focused on Behaviour: The desired behaviours and the methods to achieve change are made explicit in this approach to coaching. Toll (2004) explained that the coach will need to determine the following:

- what the desired behaviour is (e.g., all teachers will teach maths each day);
- how the desired behaviour will look in the classroom; and
- how the behaviour will improve student achievement.

Coaching focused on Attitude: This perspective suggests that the approach that is taken is dependent on the coachee's (teacher) attitude towards the innovation or change. A model known as the Concerns-Based Adoption Model (CBAM) (Hord, 1987) is an example of ascertaining a coachee's level of concern. These concerns

lead the coach to determine an appropriate focus and pathway for work with the teacher. For example; if a teacher is asked to use rich tasks in mathematics, and they are saying they are not interested (a level 1 concern), asking about how these will fit into the already crowded curriculum for maths, or how students use the manipulatives (Level 3) or sharing how they have used rich tasks for their class (Level 5). The response of the coach is expected to be different depending on the level of the coachee.

Coaching focused on Cognition: Cognitive coaching is a specific model (Costa & Gramston, 1994) that uses a process of questioning that is based on inquiry and personal discovery of the coachee. It aims to build awareness and responsibility for their practice. Cognitive coaching utilises set structure, support and feedback procedures. This focus attempts to get coachee to change their thinking by building trusting relationships where the coach and coachee are viewed as a valued and equal colleague. Both participants are comfortable challenging their own ideas and learning from each other (Costa & Gramston, 1994). Such a perspective is counter to a belief that the coach's role is one of changing teachers' thinking. Toll (2004) argues that such approaches should be used in conjunction with other coaching methods.

Coaching focused on Inquiry: Inquiry-based coaching emphasises the process used to find new understanding and practice. It can be categorised by the following elements, based on Hubbard and Powers (1993):

- driven by questions by the coachee based on evidence of student learning;
- involves data collection (student work samples, surveys, test results) as evidence to drive the focus for inquiry and review;
- may include professional reading and consulting experts in the field of expertise;
- new practices are developed and trialled and additional evidence is collected and
- continual process until the inquiry leads to the desired change.

Coaching focused on System: A system-based coach recognises that organisations need to change at the "Macro" level, before change at the "Micro" level can be approached. A systemic coach provides assistance to a school staff to examine broad educational issues. These are often the underpinning organisational health issues of the school and need to involve the principal as a key player in this change.

The importance of coaches working with Leadership Teams and principals has been well documented (Foster, 2007; Hattie, 2009; Johnson 2005). Brown (2001) argued that there are two major forms of Principal Leadership: Instructional and Transformational. Hattie (2009) defines them as follows:

> Instructional Leadership refers to leaders who have their major focus on creating a teaching and learning environment with a system of clear teaching objectives and high expectations for teachers and students. Transformational Leadership refers to leaders who engage with the teaching staff to inspire and motivate them to commitment and common moral purpose such that the teachers work collaboratively to reach goals set by the leader. (p. 83)

Robinson et al. (2008) reported that Instructional Leadership had a greater effect on student achievement than Transformational Leadership.

> The more leaders focus their influence, their learning, and their relationship with teachers on the core business of teaching and learning, the greater their likely influence on student outcomes. (p. 23)

Coaching focused on Culture: Cultural-based coaching emphasises the relationships and processes required for change. The essential element is in building trust and processes that engage and empower the staff for bringing about cultural change in their environment. Coaches cannot bring about cultural change in isolation. The entire staff must be committed to the effort and guided by the principal through strong leadership.

A strong message emerging from the literature is that the role of a coach is a complex one and there are many challenges in the implementation of a large-scale initiative. The reality for the coach is likely to involve aspects of a range of the above categories or forms of coaching, and the situation-specific context of each school, and probably each teacher, adds to the complexity. In the remainder of this paper, we will focus on a research study involving fifteen coaches from regional Victoria.

The Study

The data reported in this paper form part of research conducted with 15 Numeracy Coaches based in regional Victoria during 2009. The research question for the overall study was "Will the development of coaches' pedagogical content knowledge in mathematics enhance their efficacy as a coach?"

To support the development of skills, knowledge and capacity in mathematics, coaches were invited to take part in monthly mathematics pedagogical content forums, addressing the topic areas of fractions and algebra. The basis used was formative data collection and analysis to identify "big ideas" for student learning. Of the 15 coaches, 13 attended these sessions on a regular basis. In addition, coaches attended 16 days of professional development provided by the Department of Education, focusing on both mathematics-specific and general coaching techniques and theory.

The coaches were surveyed at the beginning and end of 2009 focusing on their:

- beliefs of coaching;
- preferred coaching behaviours;
- perceived development needs; and
- expectations of children's understanding.

The professional learning was conducted between the two survey periods. Results from the first three of these will be discussed.

The level of mathematics background and experience of the coaches varied considerably from secondary mathematics trained (3 coaches), primary trained (10 coaches) and secondary English (2 coaches). From the initial survey results,

four coaches were identified for case study analysis to provide more in-depth insights into the role of the coach in supporting teachers and how that changed over the year. They were interviewed in April and October, 2009. The four coaches were selected because they provided a balance between perceived coaching ability and confidence in mathematics. Two of the selected coaches had a high degree of experience in teacher action research within their school. The third coach had experiences across a range of schools including Adult Education and listed primary mathematics as an initial strength. The fourth coach had a strong focus on data analysis and school improvement, working as the line manager for a number of coaches, coaching in one school and regional school accountability.

Results

Beliefs and Behaviours for Coaching Teachers

Teacher coaches have a range of beliefs related to their skills, knowledge and experiences. Hattie (2009) suggested that:

> It is not a particular method, nor a particular script, nor skill that makes the difference; it is attending to personalizing the learning, getting precision about how students are progressing on this learning, and ensuring professional learning of the teachers is about how and when to provide more effective strategies for teaching and learning. (p. 245)

It is the coach's beliefs and subsequent behaviours that influence decisions in relation to the strategies they promote with the teachers to influence change in their practice.

The coaches were surveyed regarding their beliefs and behaviours. There were questions that were developed from the perspectives as defined by Toll (2004) and discussed earlier. For example, in relation to data analysis (a component of Coaching focused on inquiry):

Belief: The coaching is based on data analysis

Behaviour: Uses formative assessment for coaching conversations.

In these sections of the survey, coaches were asked questions of the kind shown in Figures 1 and 2.

> Please indicate the importance of a number of beliefs for coaching.
>
> Where a rank of 5 represents strongly agree and a rank of 1 represents strongly disagree.

The coaching is based on developing desired behaviors (e.g. maths is taught each day)	SD				SA
	1	2	3	4	5

Figure 1. Sample belief question

> Please rank the following aspects of your role using a scale from least important (1) to most important (5) aspects.

Curriculum analysis and design	Least imp.				Most Imp.
	1	2	3	4	5

Figure 2. Sample behaviour question.

We argue that coaching behaviours are related to the importance that they place on each behaviour. The higher the ranking may suggest that the behaviour might be more evident in the coaches' repertoire of skills. The survey results are presented in relation to beliefs and/or behaviours that are linked. The graphs represent coaches' responses (n=15) to survey questions in February and November. The specific statements of belief or aspect of behaviour are included as the heading or title of each graph. The graphs are box and whisper plots and the scale is 1 to 5 as in Figure 1 and 2 above.

Mathematics Knowledge for Teaching

The importance of mathematical knowledge for teaching and subsequently for coaching has already been discussed. This is further highlighted by National Council for the Supervision of Mathematics (2007) whose PRIME Leadership framework states:

> Ensuring the highest quality mathematics education for every student requires effective teaching. In order to effectively teach mathematics, a teacher must possess:
>
> Knowledge of mathematics content and pedagogy
>
> Deep knowledge of the connections among mathematical ideas (p. 22)

The results in Figure 3 suggest that coaches strengthened their belief that they should have expert knowledge of mathematics and understand the development of children's mathematics learning across the time of this study.

Eleven coaches agreed or strongly agreed that to be an effective numeracy coach they must have expert knowledge of mathematics. One coach explained: "To continually increase my knowledge of (mathematics) content helps me to be more confident when trying to improve teachers in the classroom….practice makes perfect". Fifteen coaches agreed or strongly agreed that they must have an understanding of the development of mathematics learning for children. These two aspects of mathematical knowledge are important features of coaching teachers. One coach commented:

> Even though I believed initially, interpersonal relationships are the most important; I believe professional development in understanding the pedagogy

for teaching mathematics is now the most important. As Teaching and Learning Coaches we need to have a clear understanding of the horizontal knowledge of an outcome so we can ask probing questions in our coaching conversations.

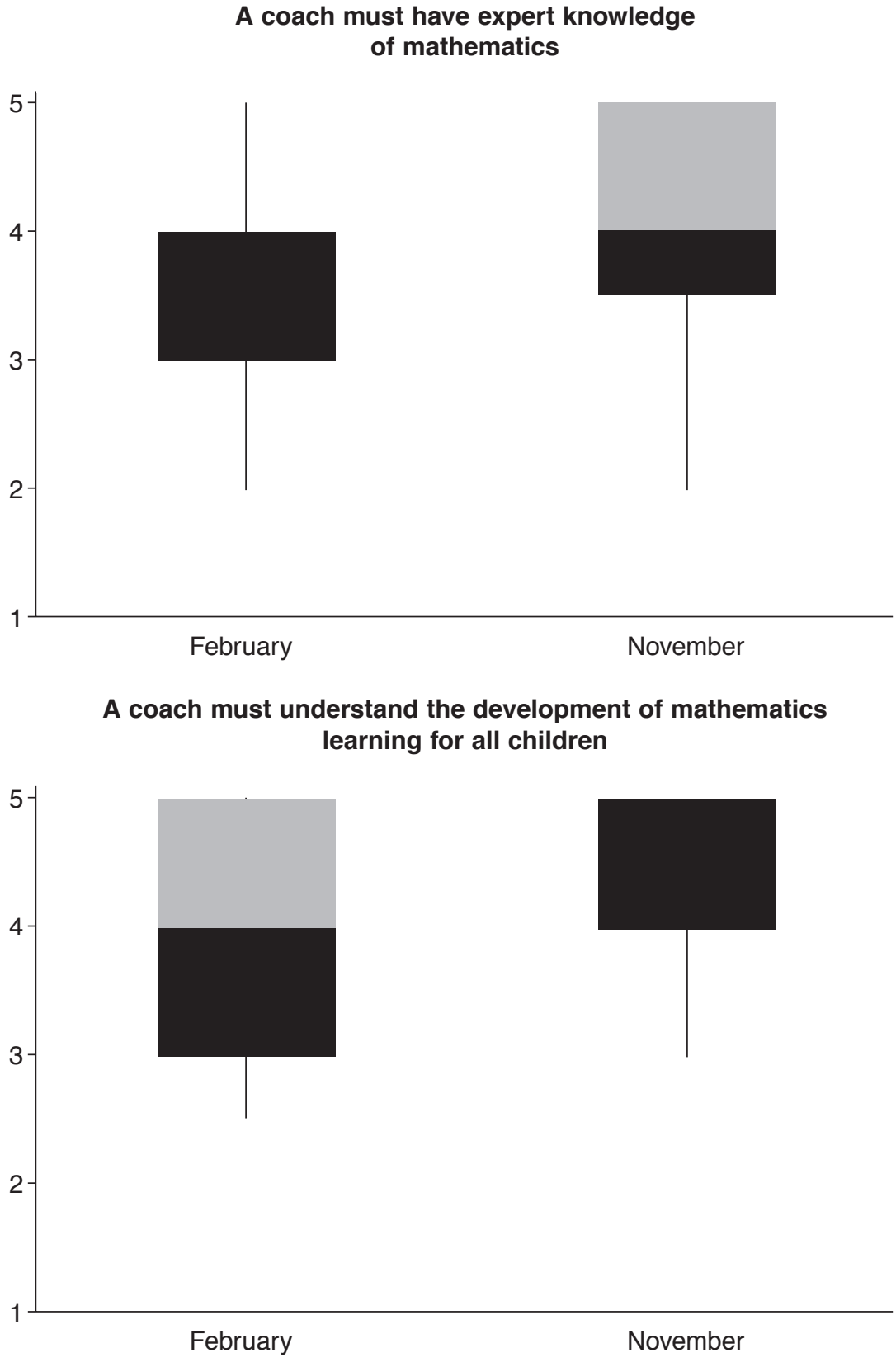


Figure 3. Graphs of responses focused on mathematical knowledge.

Use of Demonstration Lessons

The coaches' ranking of the relative importance of the use of demonstration lessons is provided in Figure 4. In the first survey, many coaches did not see the use of demonstration lessons (10 coaches disagreed or strongly disagreed) as a desired behaviour for coaching. The results show a strengthening trend towards coaches supporting the use of demonstration lessons.

One coach comments:

> Being able to provide demonstration lessons is vital to being a successful coach. It is the modelling of best practice and instructional practices in the mathematics classroom. The coaching conversations are about the decisions that you (coach) makes and this establishes credibility with the teacher. Demonstration lessons are the enabler of depth, then the conversation is around student evidence of learning and shows what is possible in the teachers classroom.

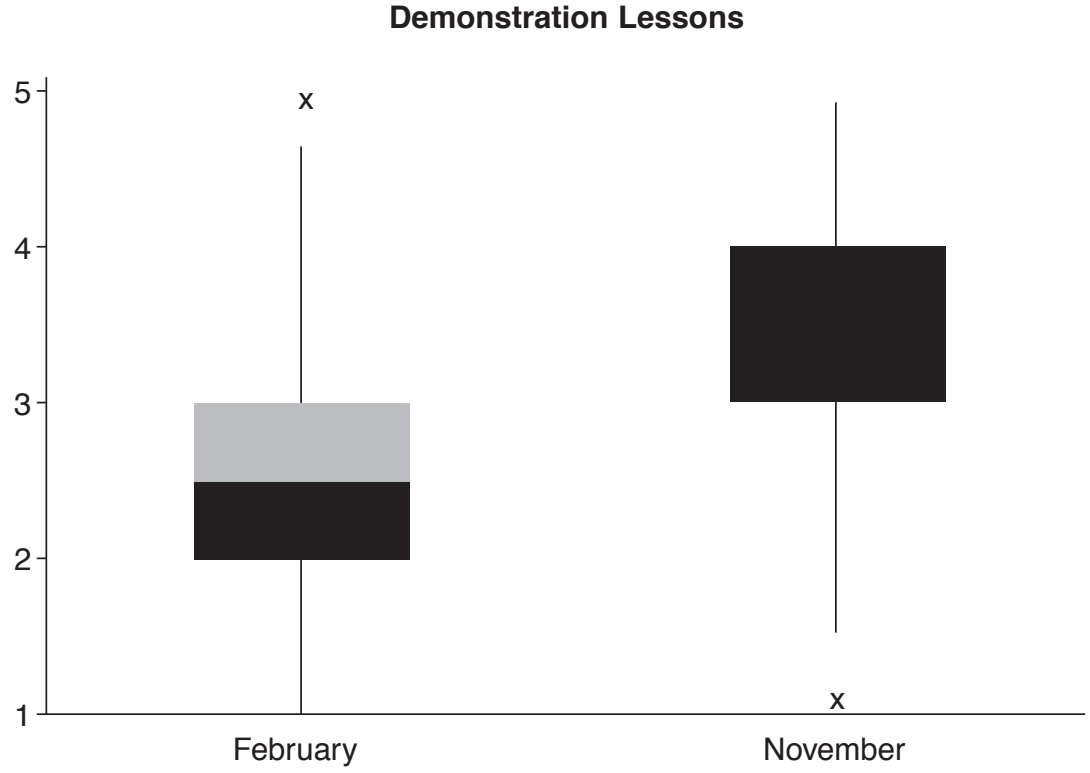


Figure 4. Graph of participants claimed use of demonstration lessons.

Data Analysis as a Coaching Tool

Figure 5 summarises the data on the importance teachers placed on the use of ongoing data analysis and formative assessment.

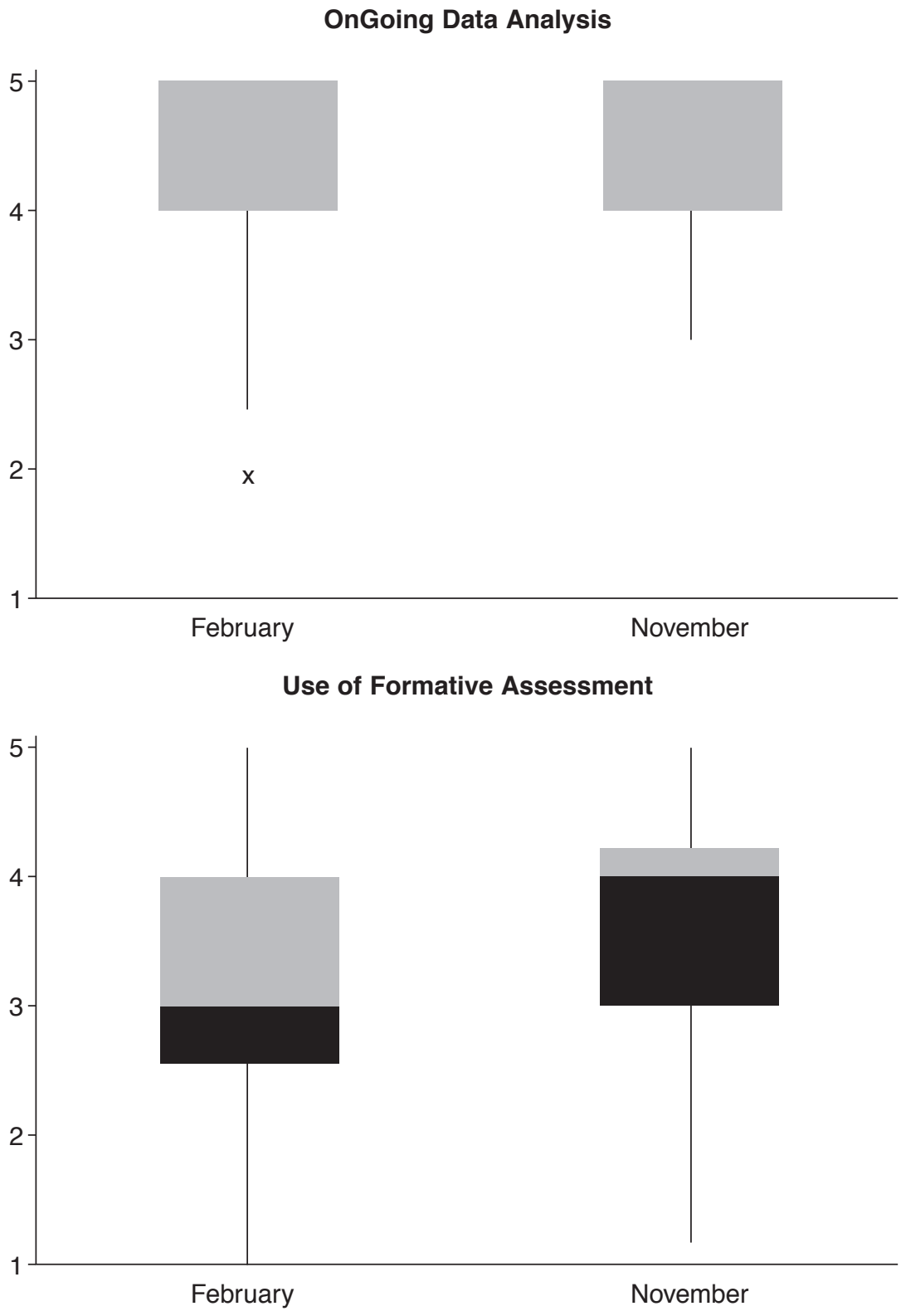


Figure 5. Graphs relating to participants use of data.

These varied results to what seem to be similar prompts poses the question of what coaches understand of the scope and definition of ongoing data analysis and formative assessment and its role in improving student learning outcomes. If coaches do not see value in using data analysis as a formative tool how are they supporting the teacher to identify the point of need for the learner? This may

suggest that while coaches have developed techniques and skills in relation to data collection and the analysis of this data, they have been unable to transfer this skill into the ongoing use of formative assessment to drive coaching and instructional decisions.

Some of the perspectives of coaching discussed earlier are used in the following selections to further explore the study of coaches' beliefs and preferred behaviours.

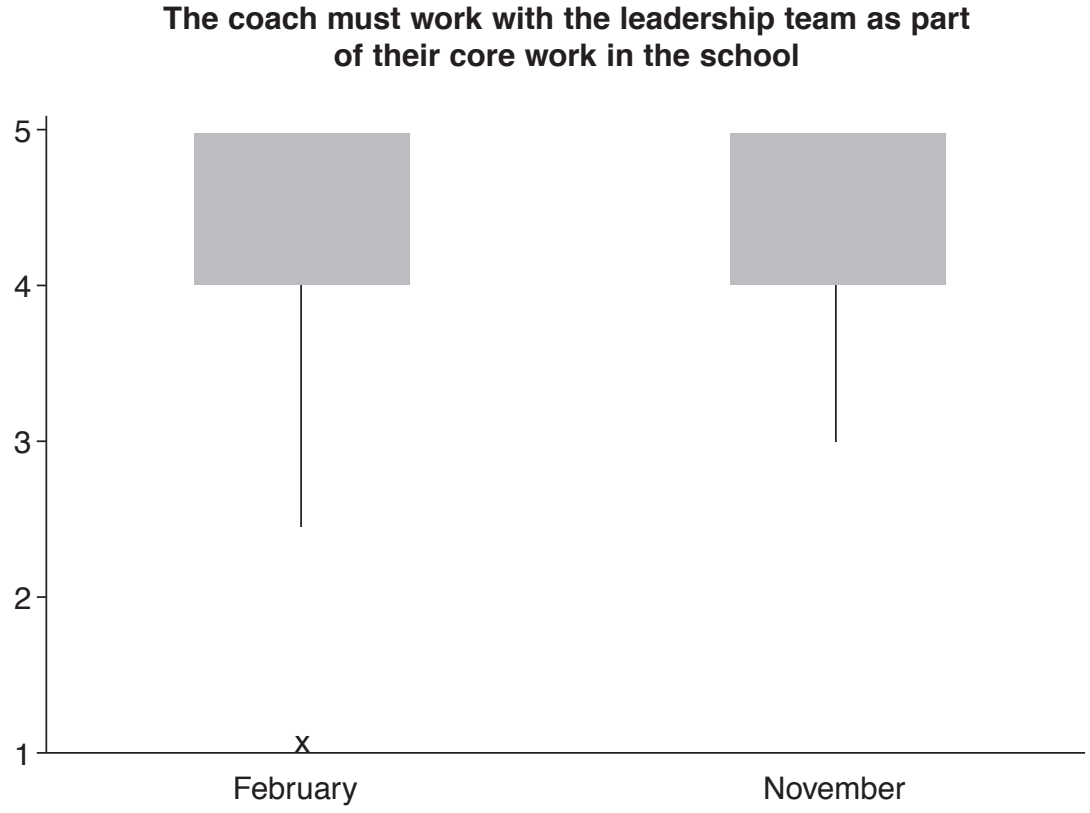
Coaching Focused on System

The following two questions, the data from which are also provided in Figure 6, were examples of coaching beliefs that are focused on Systemic (Leadership) Coaching.

The beginning of the study demonstrated a range of views in relation to the importance of working with the principal of the school. The first trend in these data worth noting is that the majority of coaches do believe that working with the principal is an important feature of coaching in schools and this strengthened during the research period. The second point is the value placed on working with the leadership team not necessarily the principal.

One coach suggests:

> I have some knowledge of this (Leadership) but my work requires me to be clear with leadership and I would like more skills in this area- sometimes it is more than just having a discussion – e.g. influencing thinking and direction.



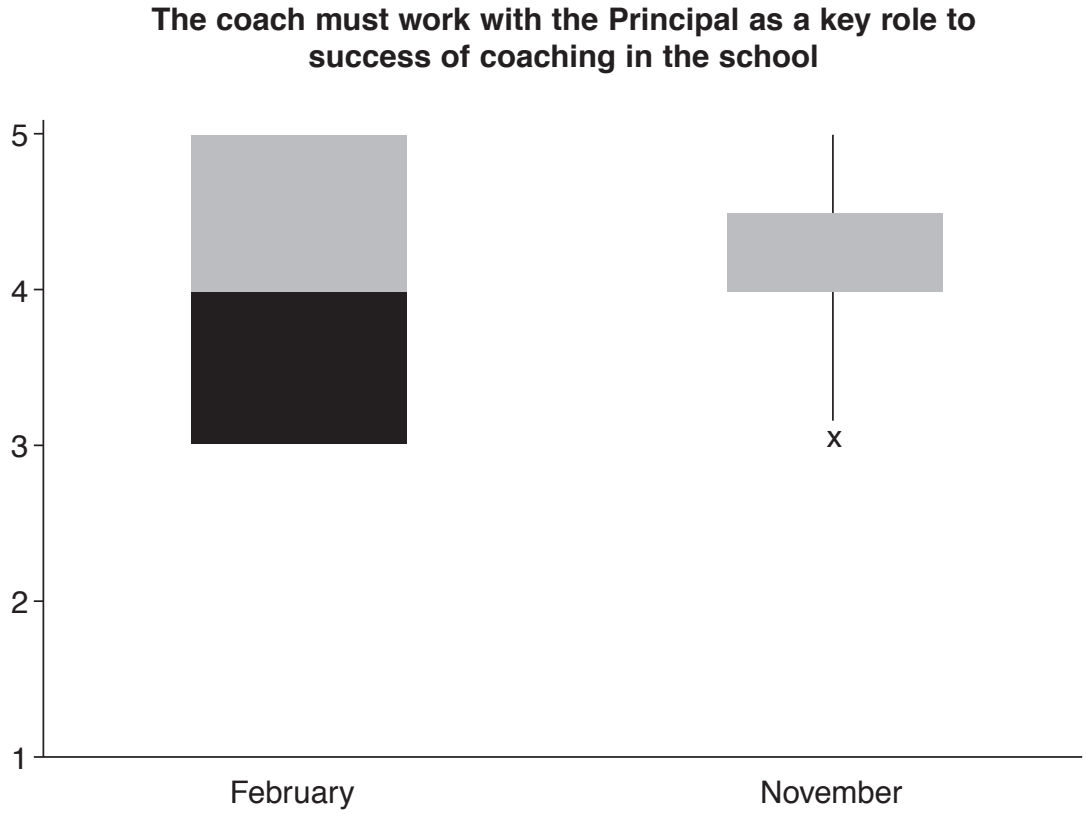


Figure 6. Graphs of data relating to leadership.

In the Victorian context, the background paper (Boyd, 2007) suggested that coaches needed to inform and establish coaching in consultation with the principal, though the coaching relationship was clearly at the teacher and classroom level. There has been a move towards an Educational Leadership model for the principals and the coaches' role may be influenced by this policy shift and working with the principal in conjunction with teachers may be viewed as more important as a result.

Coaching Focused on Attitude

Coaching focused on attitude, values the teacher's attitude to coaching or innovation. The teacher identifies the element of their practice that they would like to explore and the conversations and observations are based on the determined focus of the teacher. Figure 7 provides the questions and associated data that focus on the coaches' beliefs relating to the role of teachers concerns.

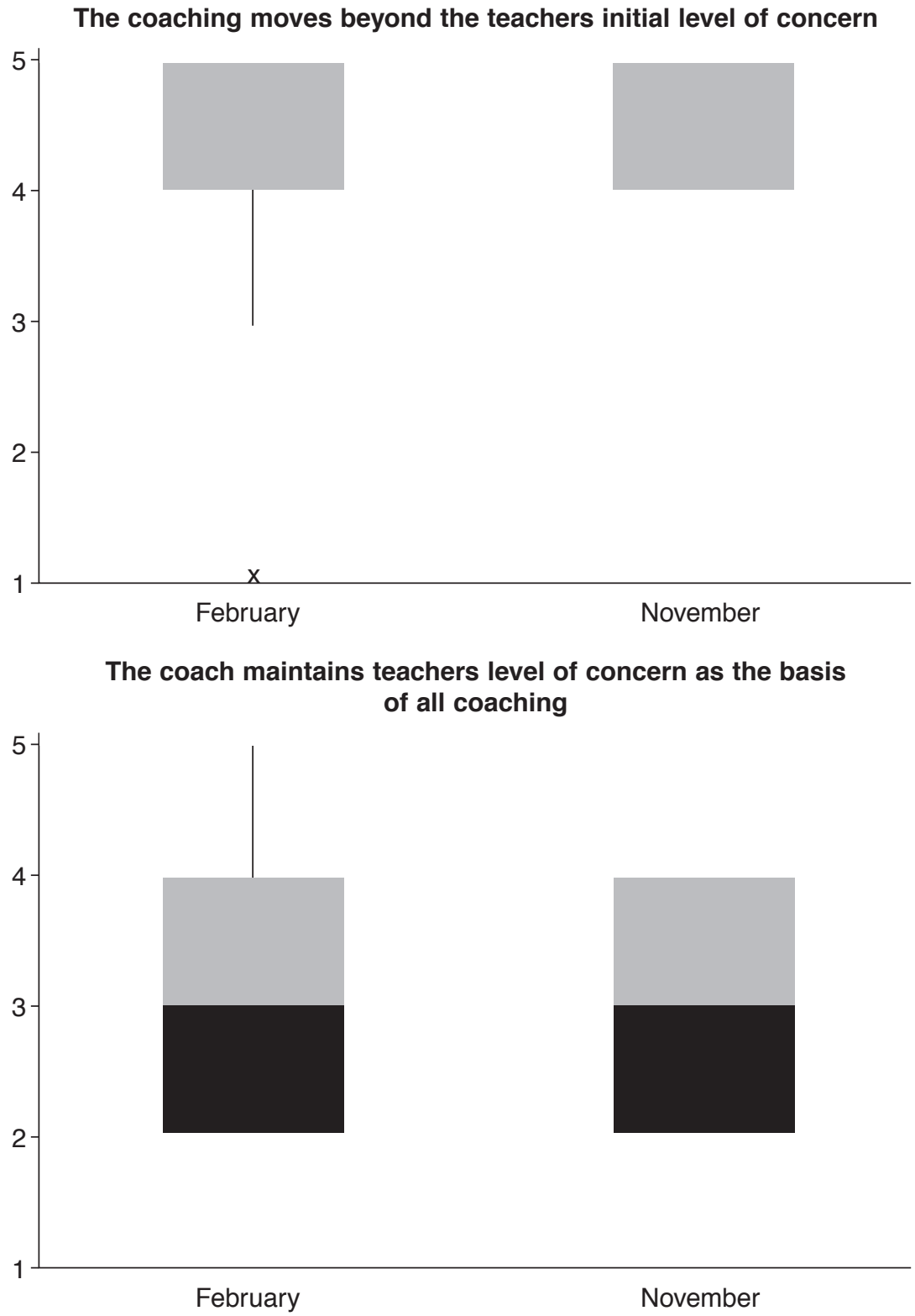


Figure 7. Graphs of coaches' responses to questions focusing on the role of teacher concerns.

The coaches demonstrated a surprising range of responses in relation to the level of teacher concern as the basis of the coaching partnership and this range increased slightly during the study. This may indicate that the coaches did not see that the concern of the teacher remains the focus of their work and that other external factors may influence their coaching. This is supported by the high

positive response to the statement – *The coaching moves beyond the teachers' initial level of concern*. It may be argued that they use teachers concern as basis of their initial collaborations but value broader considerations in their beliefs about effective coaching. A similar variable pattern is evident in the response to the prompt – *The coaching is driven by the teacher* (Figure 8).

While coaches value the use of data collection and evidence, they were not in agreement in relation to the coaching being driven by the teacher. It is somewhat surprising that as coaches are working with teachers to identify, collect and analyse student data, that this evidence is not perceived by some coaches as driving the teachers' concern and the next level of work for the coaching focus. One of the researchers made the following note:

> In my work as a coach, I have found that by working collaboratively with teachers to understand student responses to learning tasks, that the teachers' questions and concerns drive the level of learning and the next level of work with the classrooms. In my experience, when teachers develop their skills to collect and identify evidence of students learning, either by what the students are doing or saying, teachers are motivated to trial practices that elicit learning for students. The teachers level of concern in relation to content or pedagogical content knowledge determines the decision regarding demonstration, co-teaching or observation as the next level of work for the teacher. The coaching conversations focused on individual students that are representative of the cohort of students. When practices that support student learning are evidenced through assessment of observations, the practices are shared and explored further by other teacher team members in the school, facilitated by the coached teacher.

It would be interesting to tease out this question further into two foci, concerns based on data analysis and concerns based on school goals/directions

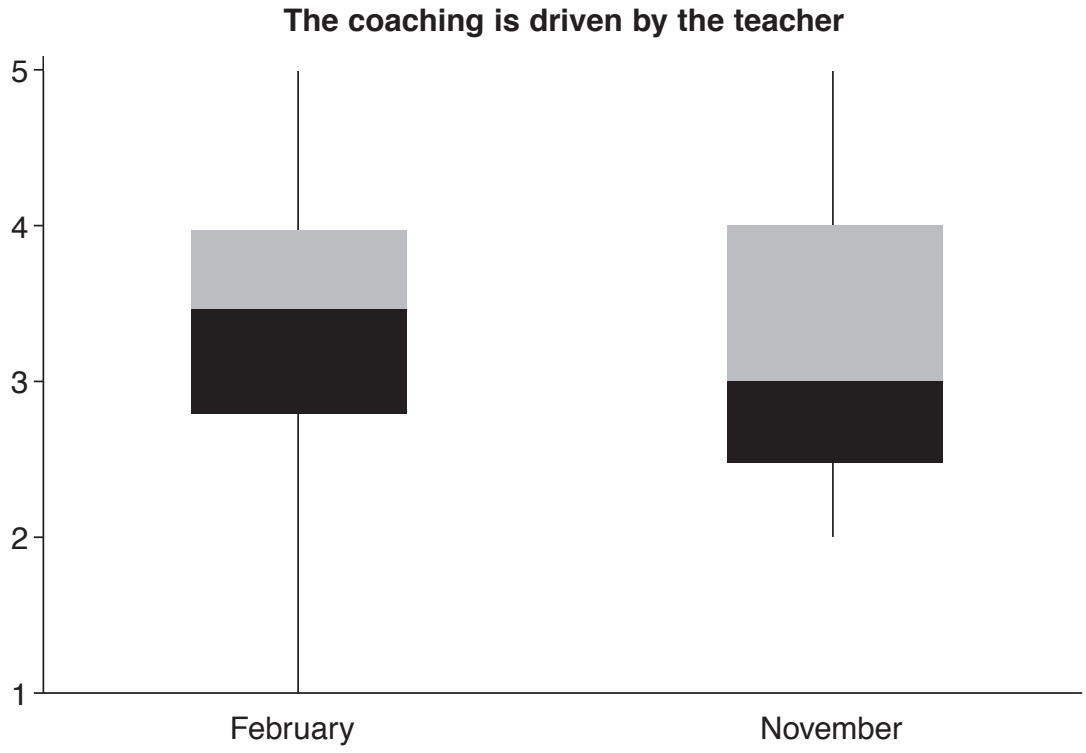


Figure 8. Graph of behavioral prompt.

It is somewhat surprising that the expectation of teacher performance lowered during the data collection (see Figure 9), and that four coaches disagreed with having a high expectation of teacher performance. Further investigation into the scope of this behaviour would be needed to understand the nature of this response by coaches. The possible impact of coaches not having a high expectation for the teachers that they are working with could result in minimal growth of the teacher, students and school.

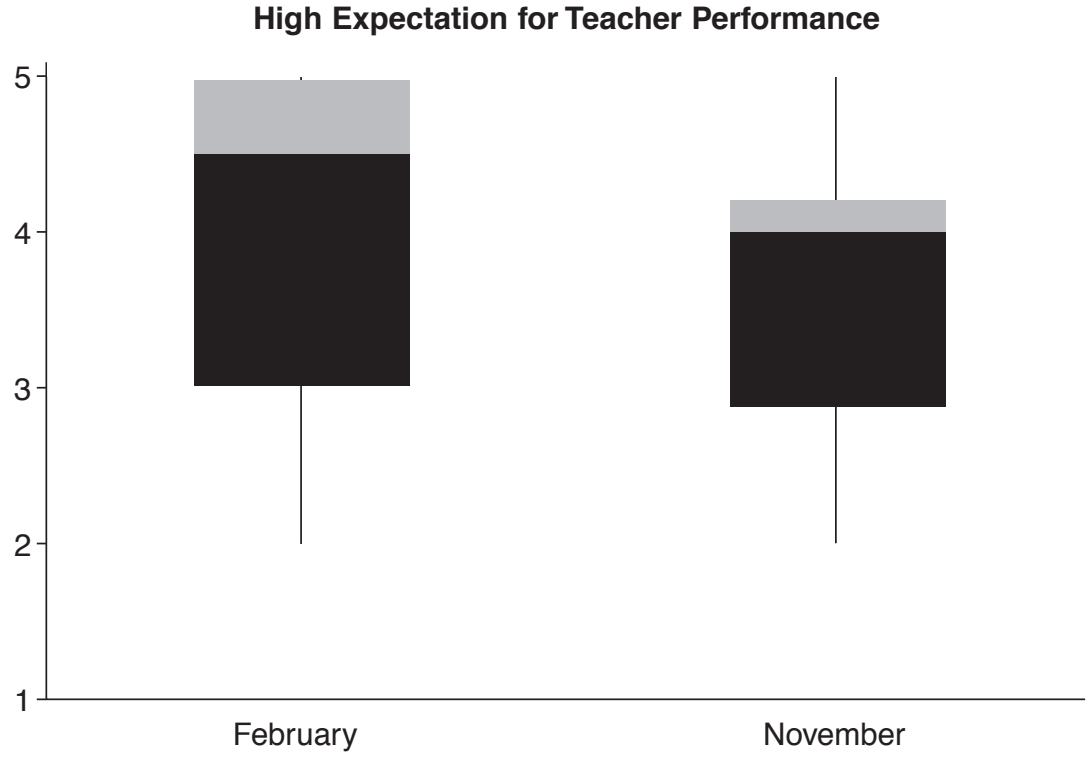


Figure 9. Graph of coach expectation of teachers.

In addition to questions relating to beliefs and behaviours, the coaches perceived learning needs were explored. As they engaged in their professional learning as well as consolidating their work as coaches it was argued that this would help answer the research question.

Perceived Learning Needs

Professional learning for coaches to build knowledge and skills to lead teacher change enabling teachers to be a powerful influence in student learning requires coaches to continually learn and grow in knowledge and skills as a coach. Determining what coaches perceive as their own learning needs is an important aspect of understanding the role of coaches.

Table 1 presents five categories of learning needs defined for coaches. These categories emerge from the literature and formed the basis of the data collection. The literature basis is provided to help clarify our intentions in the categories. As part of the survey completed by all coaches, respondents were asked to rank the

five aspects of learning or development needs from the first column of Table 1 in order of personal importance with the following instructions.

> Please rank the following aspects for your own development as a Teaching and Learning Coach.
>
> A rank order of 1 as most important aspect and 5 being the least important aspect of your learning.

The case study coaches were also given the task as a card sorting exercise (in April and October) and asked to discuss their choices and understanding of each of the categories.

Table 1
Aspects of coaches' professional learning needs and related literature

Categories of learning needs	Literature basis for the selection of the categories including the intended interpretation
Content Knowledge of Mathematics.	"deep understanding of the content area of the subject for which they are working." (Feger, Woleck & Hickman, 2004, p. 4)
related	Teachers' mathematical knowledge was significantly to student achievement (Hill, Rowan & Ball, 2005)
Instructional Skills of Teaching and Learning	Sound pedagogical practices (Principles of Learning and Teaching, (PoLT)) enable coaches to discuss instructional practices and models for explicit teaching and learning. (DEECD, 2006)
Interpersonal Relationship Development	Requires understanding the human states of mind, including verbal and non-verbal references to lead and pace teacher learning. (Costa & Garmston, 1994; Steiner & Kowal, 2007)
Instructional Knowledge as a Coach	Identify and plan for change through focussed inquiry to broaden the basis for work with teachers. "…given the vast amount of information teachers need to assimilate coaches will continually make decisions about whether to introduce something new or support further refinement of a previously explored concept or strategy." (Burkins, 2007, p.107)
Leadership Skills	"Coaches require many approaches to change and need to adapt their methods to be aligned with the goals of the school/teacher/and educational system." (Toll, 2004, p.18)

Table 2 presents the ranked perceived professional learning needs of the coaches from the survey in February and November, respectively (ranking of 1 being their highest professional learning need and 5 being their lowest need).

While the perceived professional learning needs varied considerably across the coaches involved in the study, it can be noted that there was a substantial increase in the learning need for *Content Knowledge of Mathematics*, as evidenced by the lower score. While the focus for their learning through the regional meetings was on content knowledge of mathematics (presented within the context of student learning and pedagogical content knowledge) this seems to have actually increased their awareness of their needs. It could be argued that the more we learn, the more we realise we have to learn.

Table 2
Rankings of professional development needs (February and November)

Teacher	Content Knowledge of Mathematics		Leadership Skills Development		Interpersonal Relationship		Instructional Knowledge as a Coach		Instructional Skills for Teaching and Learning	
	Feb	Nov	Feb	Nov	Feb	Nov	Feb	Nov	Feb	Nov
A	1	2	4	1	5	5	2	3	3	4
B	1	2	3	3	5	5	2	4	4	1
C	1	3	4	5	5	1	2	2	3	4
D	3	1	2	5	5	3	4	2	1	4
E	5	1	4	5	2	4	1	2	3	3
F	5	1	4	4	3	5	1	2	2	3
G	2	1	4	4	5	5	1	2	3	3
H	2	2	1	1	3	3	4	4	5	5
I	2	2	5	5	2	4	3	1	1	3
J	5	2	3	5	1	1	4	3	2	4
K	4	3	5	5	1	4	3	2	2	1
L	5	5	4	2	1	4	2	1	3	3
M	5	5	1	3	2	1	3	2	4	4
N	5	5	4	1	3	3	1	2	2	4
P	5	5	1	3	2	4	4	2	3	1
Q	5	5	3	3	4	4	2	2	1	1

The variation between coaches in each category was large, with all possible ranks represented for each aspect in both collection periods except for Instructional Knowledge as a Coach for which only four ranks were represented. This validated the need for more in-depth data collection to help to understand the individual responses.

From the initial interviews, it appeared that coaches were interpreting the categories of Instructional Skills for Teaching and Learning in two different ways: as generalised teaching skills and behaviours, or as specific content knowledge of mathematics. To further investigate this task, coaches were asked in the second survey to explain their first and last professional learning need. The coaches that highlighted *Instructional Skills for Teaching and Learning* as their first priority supported their choice with the following statements:

> Coach Q: I need to develop the continua of learning in mathematics to be established for level 4, 5 and 6 (Victorian Essential Learning Standards, yr 5-10) and how it extends to finding a problem of practice is a personal learning goal.

> Coach P: I believe Professional Development in understanding the pedagogy for teaching mathematics is the most important. As Teaching and Learning Coaches we need to have a clear understanding of the horizontal knowledge of an outcome so we can ask probing questions in our coaching conversations.

These comments would seem to refer to knowledge for teaching mathematics, with elements of both content and pedagogical content, rather than more general instructional skills; that were the intention of the category. She appears to be referring to *knowledge at the mathematical horizon* (Hill, Ball, & Schilling, 2008), a concept shared at the regional professional learning sessions. While we may argue that teachers do not need to understand the nuances of defining their own knowledge and skills, it would seem that for a teaching and learning coach who is required to support the professional learning of others, these distinctions might be better understood. The following example was an explanation for choosing *Instructional Knowledge as a Coach* that also focused on mathematics teaching knowledge:

> Coach L: I need to become more confident in sharing with the teachers the "horizonal" knowledge or the steps/gaps which have been identified in the student learning. Being able to identify and lead these for various mathematical concepts to be understood.

When the case study coaches discussed *Content Knowledge of Mathematics* as their professional learning need in October and were asked to elaborate on what aspects of mathematics teaching they found particularly difficult, three out of four specifically reported fractions, percentages, decimals and ratio questions as their most challenging.

> Coach D: …Teaching and Learning approaches that are specific to core ideas in mathematics are a focus for me. My area of focus is fractions, decimal, ratio. I have started to understand the big ideas of these, however I have a long way to go, especially in answering questions in context.

These comments by coaches have been somewhat surprising given that coaches were involved in substantial professional learning sessions both at the regional and state level specifically targeting fractions, decimals and ratio. To explore these results further and focus on individual responses, brief summaries of the case study teachers synthesised from the interview transcripts are now presented.

Case Studies

The overall results for the case studies are shown in Table 3. The rankings in April and October were based on the card sort.

Kay was first appointed as a coach in June 2008, coaching for 6 months prior to the study. She appeared to hold a strong belief and commitment for teacher action research. When Kay first completed the survey in February, she identified development of her strength in *Instructional skills for Teaching and Learning* as the highest rank. A further six weeks into the study, we started to see a shift for Kay. She still ranked the Instructional *Skills for Teaching and Learning* highly, although her greatest need to be a more effective coach was now identified as *Content Knowledge of Mathematics*. She discussed specifically the need to be able to identify confidently what students were doing in mathematics classrooms as an area for her development. When asked to predict a series of mathematics knowledge and skills that students could display during a selected mathematics lesson or specific learning task she was only able to select one key objective.

Table 3
Case study coaches ranking of professional development needs (survey and card sort)

	Content Knowledge of Mathematics				Leadership Skills				Interpersonal Relationship Development				Instructional Knowledge as a Coach				Instructional Skills for Teaching and Learning			
	F	A	O	N	F	A	O	N	F	A	O	N	F	A	O	N	F	A	O	N
Kay	2	1	1	2	5	3	2	5	2	4	4	4	3	2	1	1	1	*	3	3
Amy	1	1	2	2	4	1	4	1	5	5	5	5	2	3	3	3	3	2	4	4
Jean	2	1	1	1	4	3	5	4	5	4	4	5	1	2	2	2	3	*	3	3
Claire	3	1	2	1	2	5	5	5	5	4	4	3	4	3	3	2	1	2	1	4

*Placed along side all

Early in the year, Kay started to use demonstration lessons from the professional learning program to illustrate to the teachers she was coaching how mathematics tasks can be scaffolded to allow all students to learn. This form of professional learning gave her opportunity to unpack the mathematics within the learning tasks herself before working with teachers in classrooms. This gave

her confidence to predict the mathematics skills that students displayed by what they were able to do, say and write. As the year progressed, Kay further developed her pedagogical content knowledge through using a variety of models and specific learning tasks to meet the learning needs of the teachers and students. She explained that the rich learning tasks she chose to demonstrate were selected to further the teachers' understanding of mathematics. The start of her shift in coaching confidence was to identify and discuss evidence of student learning for some of the "big ideas" in mathematics. She also identified the use of analogies and a range of models for similar mathematical situations in the demonstration lessons, strengthened and enhanced her coaching conversations with teachers.

By the end of the study, we saw a further shift for Kay in terms of the *Instructional Skills for Teaching and Learning*. Kay explained that her general pedagogy skills could be drawn upon easily, however to be a more effective mathematics coach, this was no longer a priority. An understanding of how all students learn mathematics particularly as the content requirements, learning tasks and mathematical models become more advanced (in Kay's words, above Grade 6 level) limited her ability to coach teachers effectively. Throughout the research, we found ourselves asking if Kay saw herself as the teacher of the children or the coach of teachers. This is one of the many challenges for coaches as they transition from being a classroom teacher to a role as a mathematics coach.

Case study coaches were sent a draft of their summaries and Kay's response supports this coaching challenge:

> It was so interesting that you identified the very issue that I think is the biggest challenge to me- that is totally stepping away from the teacher role into the coach role. I think it is because I am so passionate about teachers reflecting on and building good teacher practice, and students really engaging in their learning, that sometimes I slip into a teacher role, rather than really meeting the teachers I am coaching where they are at. It is something I am aware of and am working on- a work in progress! I think I am growing into the role of a coach, and that was another reason to push myself a bit more and will take me out of my comfort zone, and hopefully improve my skills as a coach.

Amy was appointed as a teaching and learning coach in June 2008, six months before the study began. Her background included teaching across a number of primary schools and also the adult learning sector. She saw her strength as general pedagogy, and in the first interview discussed the limitation of her mathematics knowledge: "In literacy, you can get away with pedagogy; in maths you need the content for credibility. I know I have a lot to learn in mathematics. I need to develop the content first before I can develop the effective pedagogies." She saw herself as having teaching skills, but needed to know how to tell teachers what to do without offending them. By the end of the research, Amy discussed the use of data collection and evidence of student learning in mathematics as the basis for coaching teachers.

Amy identified the regional mathematics professional learning programs as

an excellent vehicle to develop both her content and pedagogical content knowledge. Amy elaborated that while she was able to solve mathematical problems, she was unable to describe how students could learn mathematical concepts in a variety of ways. The Professional Learning provided her with the models and contexts to open the learning for teachers and students. She perceived her knowledge of lower secondary mathematics as her future goal. "I need to develop my horizonal knowledge at the secondary level. The area of focus for my learning is Fractions, and in particular ratio questions in context." To extend her knowledge, Amy enrolled in a Graduate Certificate of Secondary Mathematics in 2010.

In the first interview, Amy was unable to describe any coaching structures other than telling teachers what they needed to do. By the end of the research, she had adopted a range of conversation structures, based on the Cognitive Coaching Frameworks (Costa & Garmston, 1994). It would seem that the professional learning program was able to meet Amy's needs in terms of coaching structures and conversations.

Jean was appointed as a Teaching and Learning coach at the start of the initiative in February 2008. In June 2009, she accepted a role as an Assistant Principal focusing on Teaching and Learning (Primary). Her background involved teacher development within her school context predominantly in Literacy. At the start of the research, Jean listed *Instructional Knowledge as a Coach* as her highest priority. However, less than two months later she identified *Content Knowledge of Mathematics* as her greatest need. She explained that being involved in a five day cognitive coaching program had given her the skills that she required to be able to coach teachers. She believed that refining of her coaching could only occur with strengthening of her knowledge of mathematics. In April, Jean claimed that "I need this (mathematics) to achieve. This is the most worthwhile part of my learning so far." In the follow-up interview, when Jean was then in a school leadership position, she suggested that "I need to keep going in all areas of this (Mathematics). I have only started the journey" and further elaborated: "To continually increase my knowledge of content helps me to be more confident when trying to improve teachers in the classroom."

At the start of the research, during the card sort, Jean placed the *Instructional Skills for Teaching and Learning* alongside all priorities, as she perceived that all other areas enable further refining of her skills. She showed a clear shift towards the end of the research when describing her model for teaching and learning, as moving from general teaching skills including questioning techniques and behaviour management to an approach that involved the interpretation of data and evidence of student learning. She claimed to hold core beliefs throughout the research that interpersonal skills were the underlying "given" to be a coach and argued that it is imperative that coaches know "where the teacher is at. Know how to support (them) without threatening their work."

Claire started in the initiative in a support role to the Student Learning Manager and became the Teaching and Learning Coach Manager in January 2009. In February 2009, at the beginning of the study, she began coaching at one

of the schools where a coach was unable to continue due to personal reasons. In April, she identified clearly development of *Content Knowledge of Mathematics* as her highest need, though it had been ranked lower in the survey. She answered most questions in her interview in terms of her need to develop her understanding of mathematics content. When asked to elaborate or clarify her focus area, she was unable to do so. "I really need to develop all these. I don't know what I don't know." In the final interview, Claire still considered *Content Knowledge of Mathematics* as a high priority, however she then incorporated content and pedagogical content into the one area. She was also able to identify her next level of learning in Mathematics.

> A strong knowledge of mathematics is essential for engaging in debate and rigour to inform the next level of my learning. For me this is around fractions and division. Content knowledge development where I needed and enjoyed the greatest impact on change and challenge that has led to growth. Mathematics subject and pedagogical content continues to be my priority.

At the beginning of the study, when asked to discuss her choice of *Instructional Skills for Teaching and Learning*, she only referred to how to teach mathematics. We clearly saw a shift in the November data, with Claire discussing teaching and learning models of how students learn "We need to be aware of what will get students, teachers and teams onto the 'ramp' (Vygotsky's Zone of Proximal Development, 1978) as the instructional skills for teaching and learning."

Claire did not see the role as a coach as one of leadership. She saw her role as using collaboration and shared learning but not leading: "I have deliberately positioned myself as a learner of mathematics. I have used content knowledge building as the basis for my connection to colleagues."

Summary and Implications

Coaching teachers is a complex leadership role that requires a range of skills, knowledge and practices. Throughout the study coaches were able to identify a number of important components of coaching mathematics teachers including; procedures for coaching communications (pre-brief and debrief), subject related content and pedagogical content knowledge, data collection and analysis and working with Principal and Leadership Teams.

The coaches understood the importance of data collection and analysis. Many of the coaches did not relate this behaviour to the importance of formative assessment practices to drive coaching and instructional decisions. The coaches did not identify the data analysis as the vehicle for decision making for classroom instruction. This raises the question of what is informing the on-going decisions coaches are making. Are coaches encouraging decisions based on curriculum to be taught, rather than what students are able to demonstrate as learning?

When coaching teachers, it is important for the teacher to identify and understand the evidence of their current practice by evaluating the effects of their teaching on student learning (Hattie, 2009). A focus on using evidence as a

framework for coaching conversations appears as the next level of learning for many coaches.

Many coaches are faced with challenges related to their own content knowledge of mathematics. To lead conceptually-driven conversations with the teachers with whom they are working, they need to be supported to develop their own content and pedagogy skills. Many coaches continued to raise concerns related to their own understanding of pedagogical content knowledge in mathematics. As coaches were exposed to classroom coaching experiences and focused professional learning throughout the research period, this seemed to strengthen their goals to further develop their content knowledge in mathematics. It seemed to be a case of "knowing what they didn't know."

During the research period, there were changes in the language used by the coaches including pedagogical content knowledge in mathematics, and reference to specific aspects of this, demonstrating an emergence of new understanding of how students learn mathematics. However, most coaches continued to discuss pedagogical content knowledge in isolation from subject content knowledge and were unable to make links between the two.

The findings of this study support the need for coaching initiatives to include a focus on developing knowledge for teaching mathematics, including content and pedagogical content knowledge (Ball, Thames & Phelps, 2008). It is important that coaches have strong mathematics pedagogical content knowledge to support teacher development and ultimately achieve the policy imperatives of improving student learning. In the early stages of the implementation of the initiative, there was anecdotal evidence that content-specific types of knowledge were not highly valued. This was evident in the appointment of teachers to numeracy coaching positions with little mathematics education background.

The coaches having a high expectation for teachers is an area for future investigation and development; as it is the teacher that holds the power to set more challenging goals to engage students in their learning. The implications of coaches having a low expectation for teacher performance would suggest a negative impact on student learning outcomes.

Further questions and implications include:

1. Do coaches only work with teachers who are underperforming? Is this a factor in their expectations?
2. Do coaches believe that all teachers are able to be highly effective?
3. How do coaches define high performance for teachers?
4. Although we are interested in studying the impact that different foci for coaching might have, but these would have many methodological challenges.

Conclusion

Teacher coaching requires leadership that is focussed on developing a range of skills and knowledge related to content and teaching and learning approaches. Coaches require a deep knowledge of how to develop adult learners as facilitators and leaders of student learning. This learning and reflection of

teaching is based on evidence and data of how students learn. The interpersonal and relational aspects of coaching along with the level of content and pedagogical content are also contributing factors to the success of coaching change.

The intention of the Teaching and Learning Coaches Initiative was to provide assistance to schools to improve student outcomes in mathematics. In the initial stages of this initiative coaches have identified strongly with the procedures relating to coaching teachers and also a strengthening belief in having a deep understanding of mathematics content and how it is taught.

For coaches to continually lead change in mathematics education we recommend that:

- coach capabilities are developed in relation to both content and pedagogical content knowledge of mathematics;
- coaches develop an understanding of ongoing formative assessment for leading instructional change, including informed decisions about what data to examine. That they learn to display data meaningfully to help teachers make instructional decisions; and
- coaches use content specific evidence of student learning to lead instructional change(s) at the classroom, team, school and network level.

The coaches in the study saw themselves as leading and supporting change and acknowledged the challenges in learning to coach.

> My focus for improvement is to develop confidence in being a leader and as part of a leadership team. My next level of work is to develop my capacity as a leader of school improvement across a school and the network. To do this I still need to work on developing mathematical content knowledge with a growing number of strategies and skills to use with teachers and schools. (Amy- Case Study Coach)

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Authors

Leonie Anstey, Department of Education and Early Childhood Development, Wonthaggi 3995, Australia. : Email: <anstey.leonie.m@edumail.vic.gov.au>
Barbara Clarke, Monash University, Frankston 3199, Australia. Email: <Barbara.Clarke@monash.edu>