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The Changing Roles of Science Specialists during a Capacity Building Program for Primary School Science

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Abstract: Science education starts at primary school. Yet, recent research shows primary school teachers lack confidence and competence in teaching science (Prinsley & Johnston, 2015). A Victorian state government science specialist initiative responded to this concern by providing professional learning programs to schools across Victoria. Drawing on cultural historical activity theory (CHAT), this paper reports the analysis of transcripts of interviews with 17 science specialists from eleven schools. It presents the various perceived and enacted science specialist roles, and how they changed over time. The CHAT analysis of the transcripts revealed seven different stages describing trajectories of the science specialism. The variation in the trajectories indicate the importance of the influence of the community in the enactment of the science specialism. Affordances, constraints and challenges of implementing the science specialist role are discussed.

Introduction

Declining student numbers continuing science subjects at secondary school impacts on the number pursuing careers in science (Tytler, 2007; Fitzgerald, Dawson & Hackling, 2013) and influences Australia's global competitiveness in science and technological growth areas (Chubb, 2013). Prinsley and Johnston (2015) contended that the quality of science education received at primary school is a contributing factor in this decline. The Victorian state government's response to this long-standing international issue regarding science in primary schools (Commonwealth of Australia, 2011; Osborne, Simon & Collins, 2003) was to fund primary school science specialists intending that these specialists would build capacity for the teaching of science within their schools.

The Primary Science Specialist (PrimSS) professional learning initiative provided two years of funding and training of generalist teachers in selected primary schools. These teachers were expected to lead improved teaching of science within their schools through a range of responsibilities, some consistent with the Specialist Guidelines (Victorian Institute of Teaching (VIT), 2015) view of specialist area teachers who have expert knowledge in a subject area and are responsible for the design and delivery of curricula in this area. Other responsibilities of teachers in PrimSS may be considered outside the traditional specialist role, such as working intensively and effectively with other generalist teachers in their school to build capacity in science teaching (Campbell & Chittleborough, 2014). Nevertheless in this paper they will be referred as 'science specialists'.

This study investigates the changing roles of a group of primary teachers participating

in this Victorian Government professional development initiative. The aim of this paper is to identify and explain the pathways undertaken in each school during its implementation. An activity system, using cultural-historical activity theory (CHAT), is used to describe these changes and identify factors that affect the enactment of a science specialist initiative. In doing so, this paper provides insights into the potential for transferability of the implementation of the science specialism to other curriculum areas.

Background

It is important that teachers understand deeply the curricula they teach (Australian Institute for Teaching and School Leadership (AITSL), 2011). Primary teachers' lack of science knowledge and confidence to teach science (Jones & Carter, 2007) may constrain students' development of science concepts and skills. Professional learning (PL) to build teachers' capacity for deeper knowledge of science content and pedagogy is crucial to improvement of student science learning outcomes. Since "improving teachers' knowledge, skills and dispositions is one of the most critical steps to improving student achievement" (King & Newman, 2001, p. 86), capacity building is fundamental in the implementation of any school improvement initiative (Stringer, 2013).

The intention of capacity building is to generate change in current practice including "dispositions, skills, knowledge, motivation, and resources" (Fullan, 2005, p. 4). Capacity building in the context of this study involves the collaboration of teachers, academics and school leadership teams to transform learning and teaching of science through school-based learning communities with the purpose of improving student performance (Harris, 2010). Many different approaches to capacity building in schools have been trialled, most commonly mentoring (Mathur, Gehrke & Kim, 2013) or coaching (internal: Soisangwarn & Wongwanich, 2014; external: Sailors & Price, 2015). However, inter-disciplinary arrangements providing new perspectives and expertise in pedagogical practice, have increased interest in processes such as collaborative teaching, either through school-university partnerships (Cozza, 2010) or parental-community engagement with school classes (Block et al., 2012), and in strategies such as communities of practice, across teacher communities (Admiraal, Lockhorst & van der Pol, 2012) and schools (Vescio, Ross & Adams, 2008,). Professional learning (PL) such as teacher continuing professional development programs (Qablan, Mansour et al., 2015) or government funded post-graduate courses for non-specialist teachers (Elliot & Campbell, 2015), feature to a lesser extent.

Nowhere is capacity building more important than in science education. There is a worldwide awareness that the future workforce will need highly-skilled problem-solvers, capable of innovation and invention, to anticipate and meet societal and market demands (Chubb, 2013). Chubb's (2013) report called for more science to be taught in schools to encourage more skilled people in science-related fields. Despite this urgency, there are still many barriers that inhibit the teaching of quality science lessons in primary classrooms. For many years, teaching of science has been minimised in favour of time spent on literacy or mathematics (Milner, 2011). Johnson (2006) claimed that increasing administrative roles mean that teachers lack time, support and resources to prepare and deliver science classes so relegating science classes to weekly, often ad hoc, whizz-bang experiments with little pedagogical worth. In addition, many primary teachers avoid teaching science because they lack confidence (Appleton, 2003; Nilsson & van Driel, 2010; van Aalderen-Smeets, Walma van der Molen & Asma, 2012), particularly in their self-perceived science knowledge (Johnson, 2006), or feel inadequately prepared to successfully deliver the subject (van Aalderen-Smeets, Walma van der Molen & Asma, 2012).

Improving the quality of science education in primary classrooms has the benefit of increasing student engagement and overall understanding of scientific concepts (Tytler, 2007). Building on students' science understandings has potential to foster a generation of science literate citizens and possibly increase the number of students drawn to the field of science as a career, thus increasing the number of science graduates in Australia (Chubb, 2013). As low levels of scientific literacy are often linked to a loss of public trust in scientists and a dwindling interest in, and support of, science in general (Roberts, Reid, Schroeder & Norris, 2013) education of scientifically and politically literate citizens is vital (Hodson, 2003). This premise is reflected in the Victorian government's agenda to enhance student engagement and achievements in science through a model of science specialism where specialists develop their own science and pedagogical content knowledge with a view to building capacity in generalist teachers to teach science.

This paper focuses on the role of the science specialist who was expected to work with other teachers to raise the profile of science in their school, and hence increase participation in science through improved teaching of science. This paper explores the changing roles of PrimSS science specialists. Schools interpreted this role in several different ways. This paper seeks to explicate these different roles through the lens of cultural historical activity theory (CHAT).

Cultural Historical Activity Theory

Cultural-historical activity theory (CHAT) provides a theoretical framework for a deeper understanding of factors influencing the roles of the science specialists through consideration of complex interactions in the enactment of the school-wide science specialist initiative (Engeström, 1987). The outcome of a CHAT analysis is an activity system demonstrating the social interactions between the multiple subjects and their community (Tsui & Law, 2007). An activity system can be used to explore the complex interactions between participants working towards a particular goal (Yamagata-Lynch & Smaldino, 2007), such as the implementation of the science specialist initiative in a primary school.

The components of an activity system are: subjects, tools, object, rules and norms, community, distribution of labour, and outcomes as shown in Figure 1 (Engeström, 1987, p. 78). Subjects are people involved in the activity and members of the community. "The relation between subjects and community are mediated by rules, that is, the norms, conventions, expectations, and social relations within the community which are historical and cultural" (Tsui & Law, 2007, p. 1291). The rules and norms govern the subjects' engagement in the activity with the division of labour representing the roles each subject plays in the activity system. The tools are the means by which the object is realised and the outcome is the final result of the activity system brought about by the subjects' engagement in the activity following the rules and norms, with shared responsibility for the activities of the system.

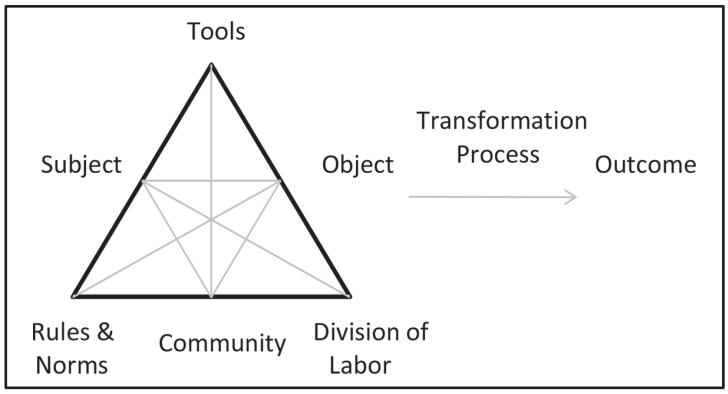

Figure 1. Engeström's activity system (1987, p. 78).

Methodology

The Victorian Government science specialist initiative (PrimSS) funded employment of 2 teachers in each school with 0.5 teaching load as science specialist for 2 years. The aims of the initiative include: 1) improving science knowledge for all teachers and building teachers' capacity to engage students in science learning; and 2) growing student interest and participation in science and to improving student achievement in science (Campbell & Chittleborough, 2014, p. 19).

Two rounds of the initiative were conducted: the first was in 2011/2012; then repeated in 2014/2015. Primary schools applied to participate in PrimSS and principals identified two teachers already at their school to become science specialists. These teachers were required to attend 15 days of PL conducted by academics at Deakin University (see details of the content of PL in Campbell & Chittleborough, 2014, p. 22) and work to implement the initiative in their school. The PL sessions focussed "on building teacher capacity in teaching Science and developing leadership skills" (p. 21).

Eleven PrimSS schools agreed to participate in the larger research project associated with the initiative: 5 from PrimSS 2011/2012 cohort; and 6 from 2014/2015. The Deakin research team consisted of 10 researchers, each responsible for data collection in one or two PrimSS schools. Several different data sampling strategies were employed: semi-structured formal interviews of 30-45 minutes in length with principals, specialists and classroom teachers; and collection of planning documents and student artefacts. This larger project attempted to address a range of questions related to the implementation of this initiative. Our study sits within this larger study with a specific focus on the roles of the science specialist as perceived by the specialists themselves. Therefore, only the formal interviews with the science specialists were analysed and reported in this paper. Each science specialist was asked the same set of questions (See Appendix 1), for example "Has there been any change to the planning and provision of the science curriculum in your school? ". Validity of data analysis was enhanced through cross checking with research colleagues who were responsible for data collection in respective schools.

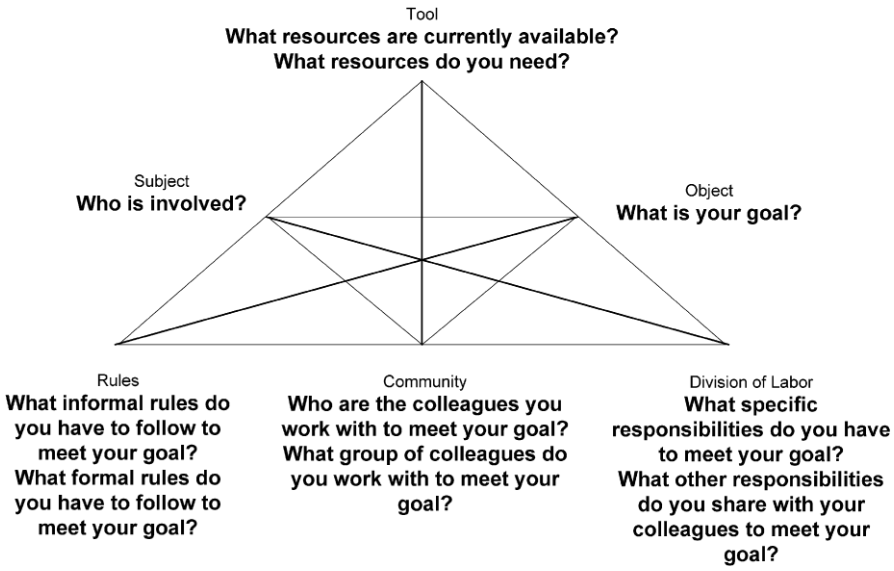

Figure 2. Yamagata-Lynch and Smaldino (2007)

A thematic analysis (Braun & Clark, 2013) was undertaken to identify themes in the transcripts of science specialists' interviews, facilitated by NVivo software. After completion of the initial coding, the researchers carefully considered the data under each theme. Each author independently checked the coding of the specialist roles (as expressed by the science specialists) undertaken by the other authors to ensure reliability of the analysis. Once these roles were identified and confirmed by referring to quotes from the interview transcripts (See Table 1), the authors returned to the interview transcripts to identify and map any changes that occurred to the specialist role over the two year period of the funding as specialists attempted to capacity-build for science teaching at their school (See Table 2).

This paper reports the science specialists' perceptions about their changing roles and the enactment of these roles in their school. In the cross-case analysis of three case study schools, discussion of the CHAT components was guided by the questions posed by Yamagata-Lynch and Smaldino (2007) (see Figure 2).

Results

Roles of Science Specialists

This study identified seven different roles undertaken by the science specialists as expressed by them. These roles include: Resourcing; Coaching; Time release; Modeling; Team teaching; Peer Observation; Mentoring; and Independent teaching. Table 1 lists these seven roles, including a description of the role and illustrative quotes from the interviews with the science specialists in which this role was described.

Role	Description of role	Illustrative quote
Resourcing	Science Specialists explore and build resources for teaching science, such as units of work, Primary Connections (PC) (Australian Academy of Science, 2015), or preparing kits.	*[We've] written some new units this year … Jane worked with those teams [Kerrie] worked with [other] teams (Jane & Kerrie, Astro Park PS)* *[Thinking]how we're going to make it sustainable once the funding stops … That's why we thought the kits – we're trying to have as much [as possible] in these kits (Melissa & Betty, Willows PS)*

Coaching	Science Specialists present professional learning sessions to a team of teachers or to the whole school in the form of discussing science content, pedagogies of science teaching, or involving teachers in curriculum and lesson planning.	*We did a PD in term 1 which was was more of an overview, we started by talking about engage rather than go through all the Es (Tammy & Madeleine, Parsons Hill PS)*
Time release	This is a traditional specialist role in which Science Specialists planned, developed and delivered the science unit to the students by providing time relief for classroom teachers.	*So last year we took it as a specialist and gave the teachers time release, so classroom teachers weren't in there with us. So I took that too (Ritchie, Bailey Road PS)*
Modeling	Science Specialists take the science class with teacher observing in the classroom.	*We wanted to model it so teachers could see that it is easy, achievable … first to model, to be the facilitator with the teachers initially observing (Tammy & Madeleine, Parsons Hill PS)*
Team Teaching	Teacher takes the science lessons with support and assistance from the Science Specialist in the classroom or vice versa.	*Teachers all geared up ready to go to do bulk of teaching and I'll be there to support them. (Hazel, Corella Valley PS)* *Specialist's primary role has been to work alongside teachers in their classroom … but not with as much support (Jane & Kerrie, Astro Park PS)*
Peer Observation	Teacher teaches the science class with Science Specialist observing in the classroom.	*This term it's about teachers doing it, but with specialist still getting resources and there as back-up. In term three teachers resourcing and teaching, and with us … doing some peer observations (Tammy & Madeleine, Parsons Hill PS)*
Mentoring	Teacher takes the teaching of science, supported by conversations with Science Specialist outside the classroom.	*In second term we meet before the lesson to talk about [questioning techniques] to make them think about their responses and after about what works, and what we'd do differently (Sonnie, Rosetown PS)*
Independent Teaching	Teacher plans and delivers science in the classroom independently.	*My team are all highly experienced teachers. I thought they just need to take over this and I'll be there as a support to them … Each teacher is responsible for their own science hour in their classroom. (Ritchie, Bailey Road PS).*

Table 1: Science Specialist Roles

Defining these roles is intended to assist in understanding the nature of the diversity of science specialist roles as perceived and experienced by the participating science specialists. However, it is important to emphasise that the roles undertaken by the science specialists did change over time as part of the capacity building process. Change in roles was strongly shaped and, in some cases, constrained by the local school context in which science specialists operated. Such changes will be described in detail below when case studies of three schools are presented, utilising CHAT as the analytical framework.

Table 2 illustrates the changes in the roles of the science specialists over time in the 11 schools. The changes in the perceived roles are presented as linear and sequential processes because, in interview, schools' pathways were usually expressed in this linear

fashion. For example, the changing role was described by one teacher from Birrell Creek as:

> *Sue (Birrell Creek PS): my role has been as a science specialist taking science classes but working with teachers. We were co-teaching but now the role has started to be our leading role. … they're[teachers] going to lead the sessions more. I'm still developing the resources up, they'll help with that when they can. … trying to get that by the end of the year that we've got some kind of system in place that's happening all the time.*

School	Changing roles of Science Specialists
South Riding	Modelling - Independent Teaching
Warrensville	Modelling - Mentoring - Independent Teaching
Astro Park	Coaching - Team Teaching - Independent & Team teaching
Bailey Road	Time Release - Modelling - Team Teaching - Mentoring - Independent Teaching
Willows	Time Release - Modelling - Mentoring - Time Release
Parsons Hill	Coaching - Modelling - Team Teaching - Peer Observation
Birrell Creek	Modelling - Coaching - Mentoring
Corella Valley	Modelling - Time Release & Coaching - Team Teaching
Rosetown	Coaching - Mentoring - Independent Teaching
Cambers Lane	Coaching - Modelling - Team Teaching
Weatley	Time Release - Modelling - Team Teaching

Table 2: Changing Roles of Science Specialists

Since the overall aim of the initiative was to build generalist teachers' capacity and confidence in teaching science to engage students and improve learning outcomes in science (Campbell & Chittleborough, 2014), success of the initiative can be related to this aim, with schools moving to individual teaching judged to be successful.

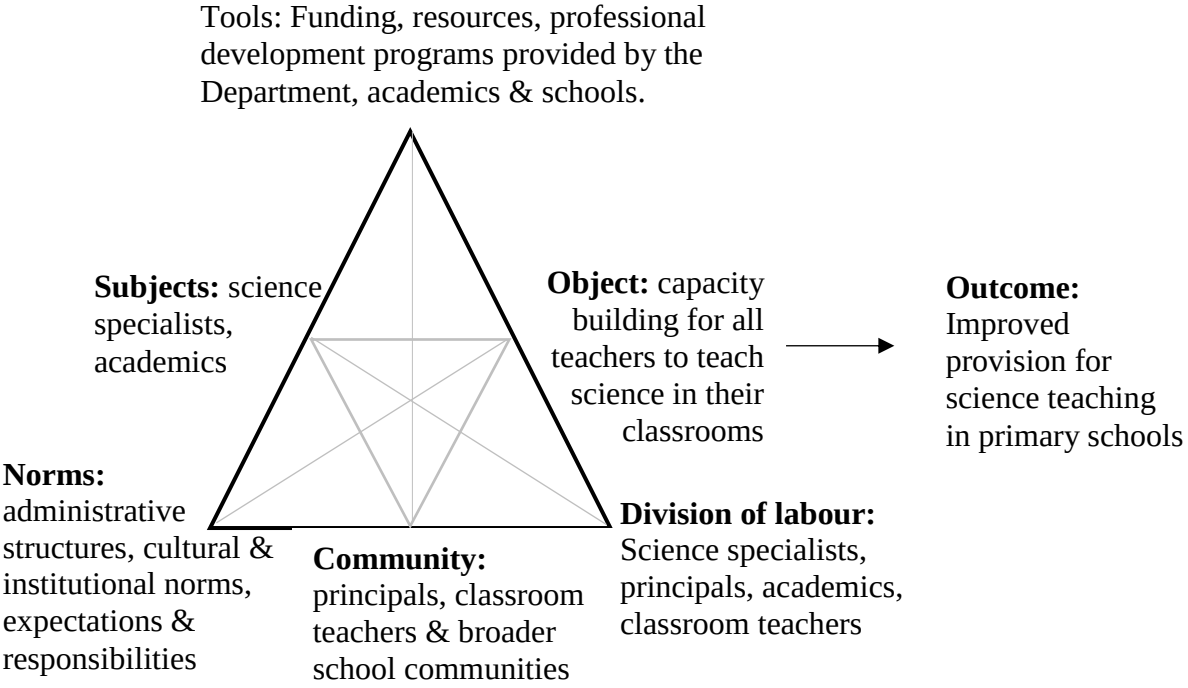

Figure 3. Activity System for Primss Program Based on Engeström's (1987, P. 78)

In order to gain insights into the nature of the roles undertaken by the science specialists and how that role changed over time, three case schools are presented to explore the impact of context on the roles undertaken by the science specialists. These schools were chosen because they exemplify the range of 'success' and perhaps challenge this definition of success. By the end of the funded period generalist classroom teachers at Rosetown PS were teaching science to their classes; Willows PS became a science specialist school; and at Weatley PS a science room with resources had been established. CHAT is used as an analytical lens to explicate reasons behind these changes with the presentation of each component of the activity system, informed by questions from Yamagata-Lynch and Smaldino (2007) in Figure 2.

Description of the Three Cases

Rosetown PS is based in a large metropolitan city near one of the six Victorian Science Specialist Centres. The school has an enrolment of 190 students with approximately 13 teaching staff. Most students come from a background of medium to high socioeconomic status (SES) (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2016). Rosetown PS participated in the PrimSS in 2014/2015.

Rosetown PS was chosen as a suitable case study because at the completion of the 2 years classroom teachers were teaching science within their own classroom as was expected by the Government initiative. The two science specialists (Sonnie & Lisa[1]) began by developing the science program for the school and associated resources. Classroom teachers were provided with the Primary Connections (PC) units to use for teaching unsupported. In the second term, each science specialist worked with a group of teachers with conversations before and after each lesson in a mentoring role. By the end of the second year classroom teachers were engaged in independent teaching of science with minimal support from the science specialists. The changing roles of the two science specialists over the period of two years were described in the interview with Sonnie.

> *Sonnie (Rosetown PS): For the first term we basically built the program, we didn't go into classrooms, we gave primary connections unit to teachers to work through themselves. That was our time just to get our head around what we were doing to come up with the plan [and], documents to support it. In second term when we did begin to coach people that was based around the primary connections unit. We met prior to the lesson we go through and talk about the questioning, and after to go through and talk about what works and what we'd do differently.*

Willows PS is a large provincial school and participated in PrimSS in 2011/2012. The school has an enrolment of 450 students and approximately 27 teaching staff with a strong, well-established leadership team. 75% of the student population come from low to medium SES background (ACARA, 2016). Willows PS began the two funded years with three science specialists (Kathleen, Gina and Narelle) designing and delivering science lessons to the classes at their school with classroom teachers given time release to attend to other tasks. Time release was followed by six months with the science specialists modelling the teaching of science with classroom teachers observing. As some classroom teachers became more confident, the science specialists supported them in a mentoring role with the classroom teacher taking responsibility of preparing and teaching science.

[1] pseudonyms

Narelle (Willows PS): for the first maybe six months we had time release to set up. We went into the classrooms probably after one term … with the teachers with us – we were modelling how to do it. It was interesting because I was only just learning too. I would have read some background information [from PC] ... So they would see we need to get that content knowledge before we can teach about it. At the end of the first year we started doing time release [for the teachers] because our technology teacher had a baby, so instead of replacing her for the last six weeks or something they said well science can just become that specialist and then the kids can actually get something beneficial out of it and then it worked so well that they decided that that's where it would stay. … [Now doing specialist classes] which is brilliant that the kids get at least an hour every week of science. And the kids will come to me with books they've been reading and say "oh, do you know what we read about today?" So they are making the connections in literacy with the science content.

The school was selected as a suitable case study based on the school's decision to revert to (and retain) the formal Science Specialist role rather than continuing to attempt to build the capacity of their generalist classroom teachers to undertake independent science teaching as was expected in the Government funded initiative.

Weatley PS, a small school located in regional Victoria, participated in PrimSS in 2014/2015 with 74% of the student population coming from low SES background (ACARA, 2016). The school has an enrolment of approximately 130 students and 9 teaching staff. This school has declining enrolments with changes in leadership and staffing. There have been four principals associated with the implementation of PrimSS in their school.

Betty (Weatley PS): Each one [principal] sees it differently and each one prioritises it differently. We struggled, we fought and fought for it not to be APT [Allocated Planning Time] but clearly we lost that fight, … having the leadership on board could really make and break you. One particular principal it was damn hard to get this … looking at being put in classrooms [or] losing art or something else as well [such as our] time fraction. We had to fight that and fight [against] that impression that you have all this time. It's very frustrating.

At Weatley PS the science specialists (Melissa and Betty) began by designing lessons and teaching science to all classes, whilst also developing kits of resources for various science topics based on PC. Like Willows PS, classroom teachers had time release to attend to other tasks. In the second year some classroom teachers were observing science specialists teaching their class, gradually moving to team teaching.

The school was selected as a suitable case study as the two science specialists left the school at the end of 2015. The kits they prepared can be used by any classroom teacher continuing to teach science. The specialists tried to capacity build classroom teachers, but were thwarted in their efforts to achieve independent teaching of science due to resistance from several classroom teachers and varying levels of support from the leadership team.

Melissa (Weatley PS): we suspect that some of the resistance [we experienced] was related to a little bit of [teachers'] nervousness, that that lack of confidence in teaching science. We saw that in the PLT [peer learning team] sessions, picking an activity that we kind of thought was fairly straightforward and you could see that apprehension and hesitation initially, but once we stepped through and we – so I think that's definitely a hurdle and it was identified as the whole reason for the initiative wasn't it, that teachers lacked the confidence in those areas.

Cross Case Analysis

The CHAT components provided a framework where the examination of each case illuminates and explicates the role of the science specialist within its real-life context.

Objective

The overarching intended goal for this initiative from the government perspective is to build capacities of all teachers to teach science in their own classrooms (Campbell & Chittleborough, 2014). Before commencing PrimSS, science was addressed in an ad hoc basis at all three case study schools. The main objective of each school for being involved in the PrimSS program was to make a more systematic commitment to teaching science.

Lisa (Rosetown PS): So prior to 2014 we weren't doing any formal science programs … it was more experiments, it was just those wow lessons.

Kathleen (Willows PS): Well before the science specialisation, science was done incidentally part of some things. … It was never like strong. … Science, to do it properly, takes time to organise, to collect resources and things like that. And it's been in the too hard basket for classroom teachers. … like there is a lot of preparation and supermarket visits and you know, preparation well before the lesson can take place.

Betty (Weatley PS): It's gone from barely being existent to being full on from prep to 6.

Raising the profile of the school in the community seemed to be a driving force for involvement in PrimSS by Willows PS, resulting in increased enrolments.

Gina (Willows PS): I think that there's been a little bit much put on the hype at the moment and I've heard the word wow factor being thrown around a lot. They're very big on their wow factor.

Kathleen (Willows PS): So we're promoting it [science at our school] in the community as well … so that's why I suppose we've gone with specialists. It's going to be [science] specialist school as long as [principal]'s here. Yeah, and she sells it. We're involved in other things like this project down the beach. We had probably 100 people from the school community there you know, collecting rubbish and doing activities in relation to marine entanglement.

Subjects

Initially, the subjects involved in the program included the science specialists and university academics who provided support and professional development. As the specialists moved back to their own schools to undertake the program, the subjects also involved the other teachers from the schools, and in some cases, the principal. Rosetown PS and Weatley PS nominated two generalist classroom teachers to become science specialists. The ability to share this role was considered essential.

Melissa (Weatley PS) a: I think that's the benefit of having 2 people in the role, not just one, because you can bounce those things, you're there to support each other, it's not just one person.

However, at Willows PS three teachers were give a 0.5 specialist load. They all attended the professional learning sessions conducted by the academics.

Narelle (Willows PS): We had four specialists across two schools, they're only like a three-class school so they, we've got 21 classes, it makes more sense to

have three teachers here and one out there.

Similarly, two generalist teachers were nominated by Rosetown PS to participate in the PrimSS, buttheir roles changed over the period of two years. In the first year, Sonie worked with teachers from prep to grade 2 and Lisa was working with teachers from grade 3 to grade 6, each with a 0.5 load. In the second year of the program, Lisa was back to teaching in the classroom while Sonnie was working full-time as a science teaching and learning coach alongside with all teachers in the school. The change of personnel was due to the difficulties encountered by the two specialists in the first year of running the program in their school as explained by Sonnie in the interview:

Sonnie (Rosetown PS): Yes and I think it's changed this year I'm in a more formal leadership role but last year I think because Lisa and I were put in this role it was an unknown and so people didn't know exactly what it entailed and what our job was and so we gradually, and we didn't know either, so we sort of had to in the first few weeks of term 1 develop how will this work and so we decided to go down the coaching model so we upskilled ourselves in coaching and I think the issues we encountered were the reluctance of people to take on feedback because they'd probably not had a real culture of feedback from other people around our teaching so some people were threatened by that I guess.

The school principal was heavily involved in driving the program in the school and she was part of the curriculum action team in the school, the role of which was to plan and oversee the implementation of the whole-school curriculum in the school. The importance of the leadership support was expressed clearly by Sonnie and Lisa:

Sonnie (Rosetown PS): Yeah it's not just a 2 year thing this is going to be going on for a long time. The support from leadership so [principal] has been fantastic I think in reflecting on that if we hadn't have had [principal] with such a strong support of this program I don't think it would be as successful as it could be. So that's a big bonus.

Lisa (Rosetown PS): Having our leadership on-board. That's critical and [principal] has been on-board and she's been very supportive and enthusiastic and I think she had an idea in her head of where she wanted this to go before we knew where we wanted it to go and I think she was waiting for us to get Sonnie and I in particular to get back to her with where we could see this developing into true inquiry.

Tools

The funding provided by the Victorian state government enabled the schools to designate classroom teachers to be trained to become science specialists. This funding was mentioned by all specialists as a key contributing factor to the success of the program at their school.

Sonnie (Rosetown PS): The commitment from the department money and time always makes a program work.

Melissa (Weatley PS): the funding is fantastic and it enables us to be in the position that we're in and hopefully [provide] the majority of our primary connection resources, … The materials, obviously the money that we've been able to spend to buy resources for the school [from PrimSS]has contributed - that's all we've got. … what we're looking at now, is how we're going to make it sustainable once the funding stops, is the big thing I guess.

Each school approached the development and acquisition of appropriate resources in

their own way. Weatley PS and Willows PS set up separate rooms where science lessons were conducted and resources kept. At Willows PS PrimSS funding provided the impetus for the school to become a science specialist school, seeking links with nearby educational institutions and organisations and building a strong school community. It was successful in accessing a number of grants to fund new infrastructure and equipment.

> *Gina (Willows PS): we got a grant which was $1500 to contribute to a program to learn about marine science and rock pools specifically within our area.*
> *Kathleen (Willows PS): Because we won that last big award ($20000) … Look I don't see a lot of problems [with sustaining science specialists] at the moment as long as we can still keep because all our bus funding and all that sort of stuff has come from grants we've won and so we need to keep applying .*

The PrimSS professional learning sessions provided science specialists with access to advanced knowledge of science content and pedagogy including a range of curriculum resources and materials, and this was perceived as pivotal in raising their confidence in science teaching. In the first year, all three schools used PC as a key curriculum resource for both science content and the inquiry-based approach embedded in the resource. For the teachers with initially low confidence in science teaching, PC units provided them with the opportunity to be comfortable with science and started to build their confidence level.

> *Kathleen(Willows PS): If we hadn't had the opportunity to do the training it would never have happened … the most valuable part of the whole training was when we were actually up and doing activities … Physically doing it cos [sic] you learn it and you remember it.*
> *Narelle (Willows PS): I've learned how to teach it the right way … I have learned not to tell answers at the start. I didn't know that.*
> *Melissa (Weatley PS): I think primary connections is a great way to start for people who are lacking confidence, which I very much did when I started, I didn't quite know where to start. But interestingly now I'm starting to read the background knowledge and then I can relate it to some of our training that we had.*
> *Sonnie (Rosetown PS): I guess having the primary connections unit because they could follow that text that actually gave them a bit more confidence. And then they sort of found that, oh actually it's not as hard as I thought it was. … so their confidence has risen.*

At Weatley PS the science specialists created comprehensive kits to aid teachers in teaching science to their classes when the two-year funding had finished. This proved to be a time consuming task:

> *Melissa (Weatley PS): we don't want it [science] to be seen as "Argh I've got to get ready for science" we want it to be "Right let's get the science kit, it's got everything we need" and then it will happen, whereas if you're not organised it won't happen - we're trying to have as much in these kits [as possible], everything that you would need. There's so much time in setting up … so we're trying to have as much of the equipment that you need possibly in there for a class teacher to pick up and go.*

Community

Within the community, the subjects relate to each other, exchanging influential contributions to the outcomes through the enactment of the activity system components. The immediate school community includes the science specialists and the general classroom

teachers in the process of capacity building in science teaching. The broader school community include parents, students, and principals who have influence on the achievement of the goals to varying degrees.

External groups such as the Education Department and school networks also have some influence on how the roles and responsibilities of the specialists were shaped but this also varies from school to school. At Rosetown PS, the whole school community is involved in meeting the goal. The principal was heavily involved in the program through working with the two science specialists to set up strategic goals and plans for the program. Sonnie and Lisa worked with different groups of teachers to support their teaching using PC and to have professional conversations before and after the teaching session. The wider school community also provided additional support to help the school to realise the goal. This include the high school and a kindergarten close to Rosetown PS.

> *Sonnie (Rosetown PS): I'm pretty confident that will happen and based on our relationships … and XXXXX High School and the kindergarten down the road has been built around science and we'll continue to foster that so we consider science to be one of the pillars for our curriculum. We want to be known as a science school so that's what we've worked hard towards and I can't see that not happening.*

At Weatley PS the science specialists canvassed widely to gain support from the cluster of other nearby schools engaged in PrimSS. The cluster was extremely important as avenues of information, ideas and support.

> *Melissa (Weatley PS): Got to have a cluster and meet with them. Our cluster is brilliant. We all get along extremely well, we meet once a month, and gosh it's good to be able to go to them and say, oh goodness are you having trouble with these …, or are you having trouble with this unit or are you, how do you set up observations.*

They also held science evenings for the broader school community including parents, students, and pre-service teacher volunteers and involved external groups with video conferenced sessions and a local secondary school all contributing to the outcome.

> *Melissa (Weatley PS): then extending that out further into having the [university] link, having XXXX [secondary] College link, so we've got a person that if we need to say "I really don't know how to explain that to staff" or "Where on earth do you buy … ", that's been really good. Community links as well, but there's so much else out there that you need the communities backing with, you can't really pull this off properly. So I think that support network is vital.*

Similarly Willows PS made a concerted effort to include and mobilise the extended school community and university contacts in their enactment of the science initiative, with science evenings, excursions and extensive utilisation of volunteers, both parents, academics and university students. The principal played a major role in securing the initial funding and accessing other ongoing sources of funding. Parents and other members of the wider community are also important in the success of their school's science program through attending excursions; writing funding applications; fund raising activities; and development of equipment.

> *Narelle (Willows PS): One of our parents is a teacher out at XXXX Uni. She's on the school council [preparing grant applications]as well … [we got] maybe an extra $120,000 that helped. We did a Bunnings excursion with Preps cos [sic] we were doing what things are made out of, materials. So we sent notes out and we had even more than one [parent] to every two students. … the dads getting involved and for the rock pools I had a lot of parents.*

Partnership with the Deakin University has provided a variety of support with undergraduate education volunteers teaching science lessons with science students providing deeper science content knowledge. Some Science and Education academics also provide ongoing support.

> *Kathleen (Willows PS): undergraduates third or fourth years come in for a couple of hours a week, they're fantastic. They work with the kids – they're cool young guys it makes it real for our kids that say "I could be a scientist too". Last term where we all went on an excursion down to Lake XXXX and each scientist had 4 or 5 kids – and they did water quality testing like you would on the field – it was great and so we go out as much as we can with these guys and into the community.*
> *Narelle (Willows PS): we've got the marine biologists that come in and help us.*

Rules

The formal rules governing the activity system are determined by the administrative structures and mediated by cultural and institutional norms that were already in place in each school along with the general regulations and expectations imposed by the funding body, such as funding and time allocation to the specialist roles, attendance at the professional learning sessions, and accountability measures in terms of the effectiveness of the program in meeting its intended goals.

The school's administrative structures and norms define the work to be undertaken by science specialist formally, using labels such as "coach" or "mentor" or "specialist" to define such roles. These structures and norms could also underpin how science specialists interact with other teachers in the school, depending on the age, experience, and administrative roles of the specialist teachers in relation to other teachers. The administrative structure at Rosetown PS allowed the vision to be imparted to teachers and reinforced through the coaching program supported by the long-term vision of the leadership team. For those teachers who initially were resistant to change, this process allowed them to see the opportunity as enriching their professional learning rather than a threat.

> *Lisa (Rosetown PS): teachers now being a lot more open to receiving feedback from colleagues - that didn't happen before last year it was a battle trying to meet with people to give feedback on lessons – people didn't want it and they took it really personally but this year people are a lot more open to it.*

Informal rules, on the other hand, are largely defined by the cultural and institutional norms at play in each school and based on a shared understanding of appropriate professional behaviour in a school context. While not being formalised and explicitly pronounced, such shared understanding and knowledge about the roles and expectations of each subject in the activity system played a critical roles in terms of how the role of the specialist was perceived and shaped. At Weatley, the "specialist" aspect of the role was endorsed strongly by teachers because of the detailed knowledge and skills brought by the Melissa and Betty in science teaching. At Rosetown PS, the strong leadership provided by the principal and the strategic coaching and mentoring program led by the two science specialists was instrumental in achieving the goals and visions set up by the school. Like Rosetown PS, Willows PS has a strong leadership team which determined the school's directions and day-to-day policies and procedures. Responsibility for the implementation of the specialist initiative devolved to the most senior of the science specialists. Teaching science at the various year levels was shared out with collective decisions on equipment and the setting up of the dedicated science room. Overarching, school-wide decisions such as the science scope and sequence were made by

the science specialists.

> *Kathleen (Willows PS): Well we've recently done a scope and sequence for inquiry as well as our science scope and sequence. Every year level has a science unit over a two year period, full on science one.*

However at Weatley PS, the leadership saw that the rolling out of science should be through time release which the science specialists found to be disappointing and restrictive especially as it made it easier for any professional learning in science to be sidelined as it was not perceived to be of immediate importance:

> *Betty (Weatley PS): And even the whole, with it being planning time we put in some time to do some professional learning for the teachers but I think due to it being APT that just got pushed back every chance… science will have to be put off till next week and then next week never came.*

Weatley PS currently has the problem of excess staff which adds an extra challenge for integrating science into the classroom. A school fee was created to ensure the continued funding of the science kits, however, there is still concern as to the sustainability of the initiative at Weatley. This meant that any resources purchased had to be carefully chosen to be easy for the teachers to use, to be readily replaced and maintained, and to be sustainable.

> *Melissa (Weatley PS): when you're resourcing, you've got to be smart about what you buy, don't just go straight out and go whiz bang, you've got to have stuff that's actually got to be used by people … because our school is in workforce bridging we have to keep a very close eye on our budget. It means that our budgets are cut to bare minimum. So we have to watch that fairly closely.*

Division of Labour

As indicated earlier, the division of labour is governed by both formal and informal rules operating in each school community. Each of the science specialists worked with a designated group of teachers. The allocation of teachers is often determined by the previous working relationship that the specialist had prior to taking on the specialist role and the grade levels that the specialists they had previously been teaching. In some schools, the two science specialists were given significant amounts of time and opportunity to work together in developing the program for the whole school (e.g. Rosetown). Similarly, the division of labour between the science specialist and the teachers differed based on the previous history of working together and the newly established working relationship as part of the specialist role. Varied degrees of engagement in the program and the differentiated division of labour are largely constrained by the broad and local school contexts, including the time, resources, funding, and leadership support provided. At Willows PS all three specialists attempted to inspire the classroom teachers of the year level they were teaching. The specialists shared the role of setting up the science room and running the initial professional learning for all the teachers at the school.

> *Gina (Willows PS): At the moment [Narelle] is attached to the 1-2 department and is able to go along to their meetings. [Kathleen] is the head of the 3-4 department and attached there, and works there. … I have a fantastic 5-6 team who were all for jumping in with me, 2 feet and getting on board.*

Over time their role changed from coaching to reverting to the traditional specialist role where the specialist takes the class for science and the classroom teacher has time release.

> *Narelle (Willows PS): So now I am a specialist so I take the preps, the 1/2s and*

the 5/6s plus an extra group with some [university volunteers]. So now when I'm taking the science the classroom teacher is on time release.

There were two part-time Science Specialists at Weatley (0.6 and 0.4) that work 3 days a week and team-teach on two days. The benefits of having two teachers sharing the role of Science Specialist was deemed to be essential to provide support for each other and other classroom teachers where having two teachers in the classroom to offer help to the students, assisted in their understanding and learning of the subject:

Betty (Weatley PS): So we have 1 class but 2 teachers in the class... And that's how we started wasn't it, we didn't do it together, we were separate, we were both doing it at the same, I'd have the preps, [Melissa] would have the 4's or whatever, and then we thought right this isn't working, we both want to come in and team teach. We're finding now one of us can step back a bit, now that they're [classroom teacher] on-board. But that did help a lot.

In the first year of the program, Rosetown had two science specialists Lisa and Sonnie, both working at 0.5 FTE in the science specialist role. Each of them were working with different grade levels, with Lisa working with grades 3-6 whereas Sonnie working with teachers from Prep to Grade 2.

Lisa (Rosetown PS): this year with our primary maths and science specialist program that we're doing, Sonnie C2D and I are the part-time science coaches. So we're allocated point 5 for science and that's, that includes our coaching time but it also gives us, we have one full day which is the Wednesday which is our, our admin time.

In the second year of the program, Lisa went back to classroom teaching while Sonnie was working full-time as a teaching and learning coach in the school.

Sonnie (Rosetown PS): I'm full time out of the classroom this year which is part science and then we've got a school review and we've got a building program happening and especially around coaching around inquiry learning as well. That's probably part of the role this year is to actually make sure that science is really well set up, it does flow on into the future.

Outcome

The outcome of this activity system is influenced by the perceptions of the science specialists and their learning in relation to science pedagogical content knowledge and the learning of their colleagues at their school. The outcome of the program is still unclear for some schools because of the ongoing changes occurring in the schools. Overall, there is some improvement in terms of the provision of science across the school in each school either delivered by the specialist teachers or by the generalist classroom teachers. While Rosetown PS had some success in building in infrastructure and resources to ensure the sustainability of the science program, Willows PS were reverted to a specialist science teaching model the sustainability of such a model is yet to be monitored and examined and Weatley PS have little teaching of science by classroom teachers.

At Rosetown PS, the strong leadership provided by the principal and the strategic coaching and mentoring program led by the two science specialists was instrumental in achieving the goals and visions set up by the school.

Lisa (Rosetown PS): this year people are a lot more open to it – and that's a big thing to allow another colleague into your classroom when you're not used to it. And now people are going "Yeah my classroom is open, you are welcome to come in and watch me teach".

Compared with Sonnie, Lisa faced a number of challenges in terms of getting teachers on board with the program and seeing the value of the program. As indicated in her interview, this was because other teachers saw her as being a young and relatively new teacher in the school. This has led to some reconsideration of the specialist roles.

> *Lisa (Rosetown PS): Yes people's unwillingness to change and seeing me as that young, new teacher because I haven't been here very long and inexperienced so that's been difficult.*

Willows PS has demonstrated major improvement in the provision of science across the whole school. However, at the time of the final interviews the leadership team of the school had decided that the teachers in PrimSS should continue as science specialists in the traditional sense of conducting all the science lessons in the school and that science would continue to be a major focus for their school. Kathleen explains this decision:

> *Kathleen (Willows PS): if anything's going to get dropped in the classroom it's going to be science, because you can't just run with it – not for meaningful science so I think eventually it would lose its passion - it would go.*

At Weatley PS the science specialists gained increased confidence through developing greater knowledge of science and improved skills at teaching science.

> *Betty (Weatley PS): I just think the level of knowledge and that that you come out of, I'm in no means a scientist, but that's not the aims of the project either but I feel so much more confident in taking Science than what I have before.*

Discussion

CHAT provided the structure to analyse the interview data to reveal the enacted roles of the science specialists at the school level. By applying this theoretical framework, interactions among the components of the activity system became evident. The tensions inherent in the activity system especially between the subjects and the school communities were identified. Comparison of case study schools for each CHAT component provided insights into the science specialist role. The focus was on the science specialists' conceptualisations of the *objective* of their activities, that is, the provision of science learning in their primary school utilising the *tool* of the activity system: the funding for the Victorian Government professional learning initiative. The negotiation of meaning of the science specialist role between school *communities* and the science specialists and the influences on the changing roles was considered. The diverse and unique context of each school influenced the manner in which the community of the school conceptualised the role of the science specialist. The roles were constrained by context and interactions with their community, so selection of prospective science specialist may have impacted the enactment of their role. Role changes often related to the reasons the school agreed to be involved in the initiative. Some schools had a previous history of science provision wanting to enhance that, whilst other schools saw it as an opportunity to bring money into the school regardless of the purpose. Future directions of the school were influential in the manner in which the science specialist viewed their role.

Another consideration was the importance of the *tool* of the activity system, that is the Victorian government funding, and the financial position of the school to continue this focus on science teaching when the funding ceased after two years. In difficult financial circumstances the science specialists' emphasis was on setting up curriculum and associated materials to support teachers continuing to teach science into the future, such as Weatley PS, whilst Willows PS with access to further funding options, returned to a specialist role as outlined by the VIT (2015). Issues regarding relationships between the science specialists, the

school leaders and other classroom teachers all impacted on the degree of capacity building of classroom teachers and hence change current practice (Fullan, 2005). School leadership was critical in the choices made and in the encouragement of other classroom teachers to participate. The selection of science specialist impacted on the degree of the school community's acceptance of their leadership role in capacity building of other classroom teachers to overcome the reported constraints on science teaching in primary schools (Johnson, 2006; Appleton, 2003; Nilsson & van Driel, 2010). It was more difficult for them to move into a mentoring role if they lacked support from their principal; were new to school; or were not strong leaders with respect amongst the other teachers. Their ability to foster classroom teachers' uptake of science teaching influenced the sustainability of the initiative in their school.

Conclusion

This study brings together developing primary generalist teachers' perceptions and opinions of their science specialist role. Its purpose is to elucidate the factors which affect the enactment of a science specialism resulting from this two year-funded PrimSS initiative intended to build capacity of generalist classroom teachers to teach science. Seven different models of enactment of science specialists' roles were identified through a thematic analysis of interviews with teachers participating in the study: Coaching/Resourcing; Time release; Modelling; Team teaching; Peer Observation; Mentoring; and Independent teaching. These models assisted in describing the manner in which the science specialists' roles changed over the two funded years in response to conditions and expectations in their schools and could perhaps inform similar in initiatives in other curriculum areas.

Consideration of the particular contexts of the 3 case study schools through the CHAT lens indicate the importance of the influence of the community in the enactment of the science specialism. By better understanding how schools respond to the implementation of a science program through the placement and training of science specialists in schools, informed decisions can be made about how best to support teachers and thus build capacity in schools for success in science.

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Appendix 1. Science Specialist Interview Questions

Science at the school or in the cluster

1. How is science in your school changing and what has been your role in that?
2. Has there been any change in teachers' practice and attitudes to science?
3. Have these changes had a positive effect on student learning? What evidence do you have of that?

Professional identity

1. What issues have you encountered across the progression of developing a whole school science program and supporting teachers to teach science?
2. What learning have you gained as a science specialist?
3. As a **leader of change** in the school's science program, what personal and professional growth do you believe has occurred for you?

Whole school approach to science education

1. What are the critical success factors which have contributed to improving the school's approach to science education? Eg - Support mechanisms, leadership, main lines of support (school council?)
2. In terms of succession plans in schools, what will be your role in the future? – elaborate on your role and what you are continuing to do.
3. If schools are continuing with the science program, what discussions were had? – What factors contributed to this decision?
4. How are you preparing the teachers for a sustainable science program?
5. How are you measuring student outcomes?
6. How do you ensure science is taught, given the other commitments and constraints operating in the school?
7. Professional learning – how have you provided professional development for other teachers in your school?