Constraints and Contributors to Becoming a Science Teacher-Leader

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Abstract

This inquiry examines the personal attribute and environmental factors that contribute to and impede science teacher-leader development. Using a narrative approach, the inquiry focuses on the experiences of three teachers in three different New Zealand primary schools (Years 1-6) as they develop in their capabilities as science teacher-leaders during sustained school-wide science delivery improvement projects. Bronfenbrenner's bio-ecological model and Rutter's views on resiliency are used as a foundation for interpreting the science teacher-leader development process. Teachers identify a variety of personal attribute and environmental factors and the interplay between these factors as risk and supportive factors contributing to and impeding their development as science teacher-leaders. Teachers also identify that their development is influenced by several proximal processes that are context and time dependent. Ramifications of this study in the context of general school curriculum, in particular, science development are also considered.

Background to the Study

Curriculum delivery improvement at the school level relies on many interrelated factors, several of which are environmental factors specific to the educational context in which the development process is intended (van den Berg, 2001). One major environmental factor influencing the effectiveness of curriculum delivery improvement is the availability of professional support (Appleton & Kindt, 1999; Davis, 2003; Fullan, 1991, 1992; Harlen, 1997; Lewthwaite, Stableford & Fisher, 2001). Teachers need support for change; not only support that encourages change but, also, support that expects change. As Fullan (1993) asserts, a combination of consensus from below (i.e., from teachers involved in the development process) and pressure from above (i.e., from individuals leading the process) to create a two-way relationship with both bottom-up and top-down influence is essential in fostering and sustaining change.

Although curriculum delivery improvement may be fostered by external support, it is imperative that schools work towards the development of their own staff members as curriculum leaders in order to sustain the development process, especially in inducting new staff members. This principle is asserted by Stewart and Prebble (1985) who state that in order for curriculum innovation projects to be successful and perpetuating, teachers must experience the active, concerned and continued support of influential and informed colleagues. Several studies have focused on understanding the factors and dynamics influencing and sustaining science delivery development (for example Lewthwaite, 2004b). Yet, little is known about the factors influencing the development

of science teacher-leaders during school-wide science curriculum development initiatives. Similar to the description provided by Venville, Wallace and Louden (1998), teacher-leaders are defined in this study as those who possess the skills to promote the teaching and learning of science. Typically, a teacher-leader would be considered to possess the leadership skills, knowledge competencies and motivation critical to promoting teaching and learning improvement. This description is suggested by Lieberman and McLaughlin who state that the support systems provided to foster curriculum development and reform need to be staffed by competent and committed people with abilities to support the learning needs of adults and build professional networks (1992).

What factors at the school level constrain and contribute to science teacher-leader development? The development of teachers as curriculum leaders within the school context is likely to be best understood by considering cultural-contextual theories of human development. One such theory appropriate for this context is posited by the work of Urie Bronfenbrenner. Bronfenbrenner's (1979) ecological theory of development proposes that development is a joint function of the person and all levels of their environment. The former includes personal attribute factors that are both biological and psychological (e.g., genetic heritage and personality) (Moen, 1995, p.1). As suggested by other studies (for example, Lewthwaite, Stableford & Fisher, 2001), personal attribute factors such as professional science knowledge, science teaching efficacy and interest and motivation are likely to be important determinants in influencing development as a science teacher-leader. The latter encompasses the physical, social, and cultural features of immediate settings in which human beings live (e.g., family, school, and neighborhood) (Ibid, p.1). Bronfenbrenner sees the ecological environment as a system of five nested structures. The first structure represents the individual. The remaining four structures range from the immediate face-to-face setting to the more remote setting of the larger culture (Hoffman, Paris & Hall, 1994, p. 47). The innermost structure consisting of family, friends and colleagues, the microsytem, is the immediate proximal setting surrounding the person directly interacts with that invite, permit or inhibit activity (Bronfenbrenner, 1989). In the context of this study, colleagues that a teacher-leader works with closely are a part of the microsystem. The developmental processes that occur within a microsystem are in good part defined and limited by the beliefs and practices of the individual's immediate setting, the mesosystem, society's blueprint for a particular culture or subculture (Hoffman, Paris & Hall, 1994, p. 47). Thus, the school's belief systems and values may strongly influence the expectations endorsed by members of a microsytem.

As an example, within the school context the belief systems held by the principal and school administration concerning the importance of a curriculum area are known to influence the school's ethos for a curriculum area (Lewthwaite, 2004a). The third structure, the exosystem system, refers to environmental influences that do not involve directly the developing person but still influence the setting in an indirect manner. As an example, the community's aspirations for the emphasis placed on science as a curriculum are also known directly impinge on school-based policy decision making (Lewthwaite, Stableford & Fisher, 2001). Finally, the most removed structure, the macrosystem, refers to societal and cultural ideologies and laws that impinge on the individual. In the context of this inquiry, national curriculum agendas and compliance statements are likely to influence the school's response to science as a curriculum area.

Of importance to this inquiry and science teacher leadership is the acknowledgement that supporting processes within these overlapping environments are 'engines' for development. As well, Bronfenbrenner (1997) further suggests that these engines are context-, time- and process-dependent. This implies that the factors influencing science teacher-leader development cannot be generalized but, instead, are unique to each individual; their personal attributes; the context in which their development takes place; the time (life-span) at which the development is occurring; and the processes each person experiences during the development.

This suggestion is endorsed by research in other areas of human development. For example, Rutter's research in resiliency extends this understanding of how bio-ecological attributes can influence development. He defines resiliency as the capacity for successful adaptation despite challenging circumstances (Rutter, 1977, 1987). He suggests that both 'risk' and 'protective' factors contribute to an individual's development and resiliency (Rutter, 1977, 1987). Risk factors are personal attribute factors or processes in the individual's environment (e.g., low science-teaching efficacy, discouraging comments from colleagues) that contribute to negative trajectories in development. Aligning his work with Bronfenbrenner's, Rutter suggests that protective factors are the 'engine' processes possessed by an individual (e.g., positive self-concept) or in an individual's environment (e.g., a committed family member) that contribute to positive outcomes and consequence in personal development. Risk and protective factors, again, are suggested to be person, context and time dependent.

The ideas posited by Bronfenbrenner and Rutter would suggest that understanding science teacher-leader development is best investigated within a research inquiry where one is able to examine the personal attribute and environmental processes and the interplay between these processes that influence the development process over a period of time. Such is the focus of this research inquiry.

Research Methodology

All three science teacher-leaders in this study were teachers within schools that were involved in extended school-wide science delivery development projects starting in late January and ending in November of the 2002 school year. (Author's note: the school year in New Zealand runs from late January to early December). The schools (to be referred to as City, Rural and River) were all Year 1 to 6 elementary schools in New Zealand. Typical of most elementary schools in New Zealand, all teachers in each of the schools (aside from Te Reo Maori language specialists in Rural and City School) were responsible for the teaching of all curriculum areas including science. As part of their ongoing school development program each school had selected science as its curriculum area of focus for the school year and had contacted the author to assist in the science development project. Rural and River School's primary motivation for the development focus was fueled by a recent external audit by the Education Review Office (ERO) which had identified the schools' attention to science as a curriculum area as unacceptable and in need of immediate attention (Author's note: New Zealand schools are audited on a regular basis for curriculum compliance by the Education Review Office). Conversely, City School was intrinsically motivated to improve their delivery of science as part of an end-of-year school curriculum self-review process. All schools indicated to the author through their principals that they wanted the science development process to focus on developing teacher capability in science subject matter, pedagogical content and procedural knowledge specific to providing authentic investigative opportunities for children in line with the expectations of the national science curriculum.

The professional development program implemented in each school responded to initial findings identified through the application of an on-line, statistically validated, diagnostic science curriculum evaluation instrument, the *Science Curriculum Implementation Questionnaire* (SCIQ).

The SCIQ is a seven-scale, 49-item questionnaire that provides information concerning the personal attribute and environmental factors known to influence science program delivery at the classroom and school level (Lewthwaite, 2001). It has been used successfully as a foundation for science delivery development in a variety of contexts (see for example, Edmonds & Lewthwaite, 2002; Gulliver & Lewthwaite, 2003; Lewthwaite, 2004 a, b; c; Payne & Lewthwaite, 2002). The scales of the SCIQ have been developed with the intent of gauging staff perceptions on a 1 (Strongly Disagree) to 5 (Strongly Agree) in areas that are identified as major impediments to science program delivery both nationally and internationally (Lewthwaite, 2001). Four of the scales pertain to the school environment. These environmental scales include School Ethos; Professional Support; Time; and Resource Adequacy. The remaining three scales relate to teacher personal attributes. These include Professional Science Knowledge; Professional Interest and Motivation; and Professional Adequacy. The details of the procedures used in the development and validation of the SCIQ and the protocols associated with its use are presented elsewhere (Lewthwaite, 2001; Lewthwaite & Fisher, 2004, 2005). A description of each of these scales is provided in Table 1 below.

Table 1: *Scales and Sample Items from the Science Curriculum Implementation Questionnaire*

Scale	Description of Scale	Sample Item
Resource Adequacy	Teacher perceptions of the adequacy of equipment, facilities and general resources required for teaching of science.	The school has adequate science equipment necessary for the teaching of science
Time	Teacher perceptions of time availability for preparing and delivering the requirements of science curriculum.	Teachers have enough time to develop their own understanding of the science they are required to teach.
School Ethos	Overall school beliefs towards science as a curriculum area. Status of science as acknowledged by staff, school administration and community.	The school administration recognizes the importance of science as a subject in the overall school curriculum.
Professional Support	Teacher perceptions of the support available for teachers from both in school and external sources.	Teachers at this school have the opportunity to receive ongoing science curriculum professional support.

Professional Adequacy	Teacher perceptions of their own ability and competence to teach science.	Teachers at this school are confident science teachers.
Professional Science Knowledge	Teacher perceptions of the knowledge and understandings teachers possess towards science as a curriculum area.	Teachers have a sound understanding of alternative ways of teaching scientific ideas to foster student learning.
Professional Attitude and Interest	Teacher perceptions of the attitudes and interest held towards science and the teaching of science.	Science is a subject at this school that teachers want to teach.

The SCIQ was applied in each of the three schools prior to the commencement of the professional development program. This meant that in each school all teachers with responsibility for the teaching of science completed the questionnaire (City, *n=12*; Rural, *n=11*; and River, *n=9*). The information collected from the instrument application was processed by following a specified, straight-forward procedure of analysis. Mean (average) calculations were performed to identify general trends in perceptions for each of the seven scales. As well, standard deviations were calculated to determine the degree of consistency among respondents for each scale. On the basis of these data, scale profiles were developed. The data and interpretive scale profiles from each application were shared by the author with the appropriate school as a foundation for staff decision-making about areas to address during the professional development program.

The professional development provided in each school, although unique to each school, was based on four premises. First, research would inform practice. As Loucks-Horsley, Hewson, Love & Stiles (1998) suggest the staff and author believed that internal and external knowledge and knowledge from practice as well as research are all valid and important. It is the artful professional development design that combines these most effectively. The research literature (for example, Briscoe & Peters, 1997; Dillon, Osborne, Fairbrother, & Kurina, 2000; Loucks-Horsley *et al*, 1998; Peers, Diezmann, & Watters, 2003; Suppovitz, Mayer & Kahle, 2000; Suppovitz & Turner, 2000; Venville, Wallace, & Louden, 1998) gave a clear picture as to what personal and environmental attributes were critical to successful professional development and were combined into the organization of the development agenda. Time, professional support and physical resources were to be allocated. Administration and teaching staff clearly endorsed and were to support the agenda.

Second, as part of this process, it was ascribed that teachers learn new content and pedagogy as a result of their reflections about their practice and their collaborations and problem-solving activity with colleagues and content and pedagogy experts. In this sense reform and improvement were to be collaborative activities (Davis, 2003). Third, similar to that posited by researchers and educators in science education (Suppovitz, Mayer & Kahle, 2000; Suppovitz & Turner, 2000), the professional development program negotiated was believed by the author and participating staff to (1) model inquiry forms of teaching; (2) be sustained; (3) engage teachers in concrete teaching tasks; (4) focus on the development of teachers' subject-matter and pedagogical content knowledge; (5) be grounded in specific professional development standards; and (6) be embedded within a reform plan for the school to improve the quality of instruction provided by teachers to students. This last aspect encouraged the professional development to give attention to improved instructional practice not just specific to science. The staff collectively wanted the professional development to focus on teaching methods that assisted students in meaningful learning. Of particular importance was establishing that learning was enhanced by an educational environment that engaged students in active, collaborative, constructive, intentional and authentic learning experiences (Jonnassen, Peck & Wilson, 1999). Finally, the professional development agenda was designed to simultaneously foster the development of one science teacher-leader in the school. An external professional development provider would be designated to assist the teacher-leader in leading the school development process and simultaneously provide extra support to the teacher-leader in areas considered beneficial to her development. The goal of this particular focus of the professional development agenda was to foster the development of a current teacher in her leadership skills, knowledge competencies and motivation critical to promoting the learning needs of the science teaching staff.

Typical of many New Zealand elementary schools a teacher held curriculum responsibility (referred to as a science lead-teacher) for science in each of the three schools (City-Julie; Rural-Wendy and River-Bronwyn (all pseudonyms)). Each of these teachers shared a similar role in that they were primarily responsible for ensuring the school was resourced for the teaching of science. In respect to the description of teacher-leader provided by Venville, Wallace and Louden (1998), all three teachers would not have suggested that they possessed the necessary skills to promote the teaching and learning of science at this stage of their professional journey. All three teachers had a strong interest in the teaching of science and an equivalent science background. They all had taken

senior biology in high school. As well, they had been science majors during their Bachelor of Education teacher education program and, consequently, had completed several curriculum methods and science content knowledge courses during their undergraduate degree. All were recognized by their colleagues and their school's senior administration as competent and confident teachers of science. As part of the overall school science development program, it was agreed amongst school administration, teaching staff and the project facilitator that during the year effort would be made to engage the lead-teachers in a variety of in- and out-of-school situations to facilitate their development as science teacher-leaders. These situations included extra contact time with the program facilitator devoted to planning, assessment and development of content and pedagogical knowledge; attendance at provincial science professional development workshops; and working individually and in collaboration with the program facilitator in leading the in-service at their home school. Participants were encouraged to keep a self-reflection diary with monthly entries during the school development process; in particular emphasizing their 'life story' as developing science curriculum leaders. On three occasions during the school development initiative (commencement, during and end) these reflections became the focus of discussion between the author and the teacher leader. Teacher-leaders were invited to consider how their development was influenced by personal attribute and environmental factors as risk and protective factors and the interplay between these factors. In particular, the focus of the reflection diary and follow-up interviews was to consider what conditions of their personality and immediate school setting invited, permitted or inhibited their developmental activity (Bronfenbrenner, 1979, 1989; Rutter, 1987).

The essential questions that guided this research inquiry were: (1) What factors do teachers perceive contribute to or impede their development as science teacher-leaders? and (2) Can Bronfenbrenner's bio-ecological model and Rutter's ideas on resiliency be used to understand the dynamics among these factors in explaining science teacher-leader development? Since this inquiry examines people's stories of their own lives through their personal accounts of the relationship amongst self-relevant events across time it subscribes to a narrative-approach methodology (McAdams, 1989). What was learned throughout this study was informed by the experience of the researcher through the collection and interpretation of the data and the existing literature pertaining to human development in the context of school and community environments. As the data from the

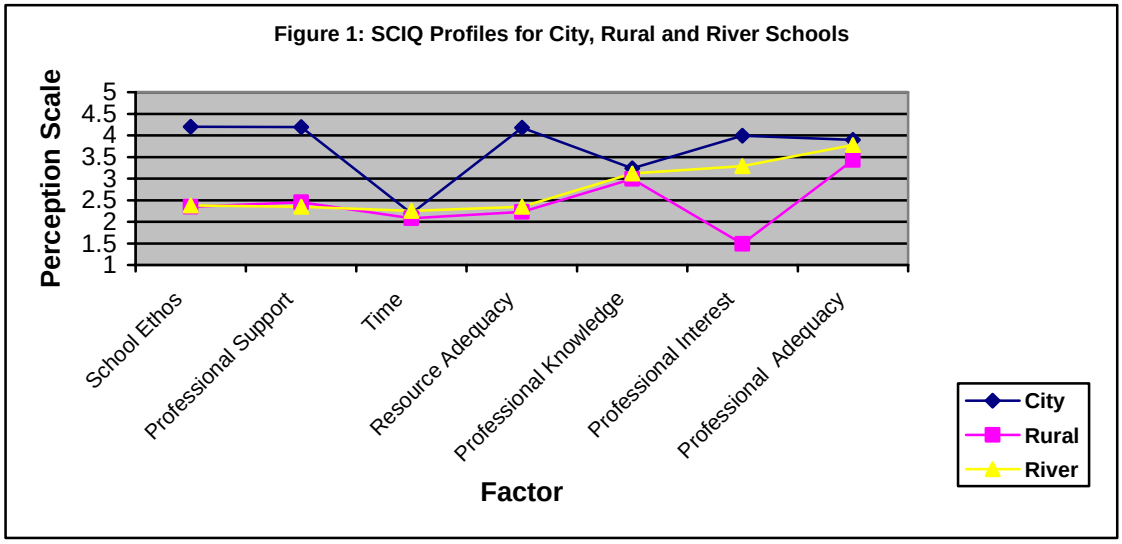
teacher candidates comments were analyzed, tentative assertions addressing the research purpose were generated (Erickson, 1986).

Results and Discussion

The data collected from the SCIQ application at each of the three schools are illustrated in Table 2. The mean values for each of the seven scales are also illustrated in Figure 1. The profiles presented in Table 2 and in Figure 1 illustrate the similarities and differences in the schools and serve to describe the context in which each of the settings the teacher-leaders were working.

Table 2: *SCIQ mean ($\overline{X}$) and standard deviation (SD) profile data for City, Rural and River Schools (City, n=12; Rural, n=11; and River, n=9).*

School	**City**		**Rural**		**River**	
Mean ($\overline{X}$) **Standard Deviation *(SD)***	**Mean ($\overline{X}$)**	**Standard Deviation *(SD)***	**Mean ($\overline{X}$)**	**Standard Deviation *(SD)***	**Mean ($\overline{X}$)**	**Standard Deviation *(SD)***
School Ethos	4.20	0.34	2.35	0.35	2.38	0.67
Professional Support	4.19	0.32	2.45	0.24	2.38	0.44
Time	2.19	0.21	2.08	0.34	2.25	0.36
Resource Adequacy	4.18	0.23	2.23	0.34	2.35	0.24
Professional Knowledge	3.24	0.58	2.99	0.25	3.12	0.24
Professional Interest	3.99	0.34	1.49	0.45	3.29	0.70
Professional Adequacy	3.90	0.35	3.43	0.43	3.78	0.25



It is evident that City School had characteristics quite different, for the most part, from Rural and River Schools. The data indicated that City School teachers perceived that the school placed a high priority on science as a curriculum area and that this was reflected in the administrative decisions and actions of the school. The overall school ethos was seen to be contributing positively to the teaching of science (Table 1: $\overline{X}$ =4.20). City School teachers also perceived that they were well-supported and well-resourced as a school to deliver science as a curriculum area (Table 1: $\overline{X}$ =4.19 and 4.18 respectively). As well they perceived themselves to be professionally interested and adequate in teaching science (Table 1: $\overline{X}$ =3.99 and 3.90 respectively). Reflecting the focus of their imminent professional development agenda, teachers had neutral perceptions of their professional science knowledge (Table 1: $\overline{X}$ =3.24). City School teachers also identified time availability as an impediment to more effective science delivery (Table 1: $\overline{X}$ =2.19). Rural and River Schools' profiles showed many similarities. They perceived their schools did not place a high priority on science as a curriculum area (Table 1: $\overline{X}$ =2.35 and 2.38 respectively); did not support teachers in the teaching of science (Table 1: $\overline{X}$ = 2.45 and 2.38); identified time as a factor impeding science delivery (Table 1: $\overline{X}$ = 2.08 and 2.25) and were not well-resourced for the teaching of science (Table 1: $\overline{X}$ = 2.23 and 2.25). Teachers at both Rural and River Schools had neutral perceptions of the adequacy of their professional science knowledge (Table 1: $\overline{X}$ =2.99 and 3.12)

but quite positive perceptions of their science teaching capability (Table 1: $\overline{X}$ =3.43 and 3.78). River School had a markedly lower positive perception of their interest in teaching science as a curriculum area (Table 1: $\overline{X}$ =1.49) than Rural School (Table 1: $\overline{X}$ =3.29).

Initial Accounts of Science Teacher-Leaders

Three statements guided the initial interviews at the start of the professional development agenda with the science teacher-leaders. First, each of the three science teacher-leaders was asked to comment on the accuracy of the profile data specific to their school. Second, the teacher-leaders were asked to identify their personal aspirations in terms of a science teacher-leader trajectory. Third, the teacher-leaders were asked to consider what personal attribute and environmental factors they expected to influence the achievement of these aspirations.

A. City School: Julie's Reflection

Julie asserted that the data profiles for City School reflected the emphasis that the school placed on science as a curriculum area (School Ethos $\overline{X}$ =4.20).

"Science has always held a high priority as a curriculum area. The administration expects science to be taught and for what is taught to be challenging and of interest to students. There is a public perception that we give attention to science as a curriculum area. This is reflected in a variety of decisions we make including staffing decisions. Teachers with a capability in teaching science know that this capability will be acknowledged when they apply for a job here".

She also acknowledged that there were areas of concern for science as a curriculum area; areas that similarly had been evident from the school profile data (Time $\overline{X}$ =2.19, Professional Knowledge $\overline{X}$ =3.24).

"We know that although science has a high status, we needed to improve its delivery. Time is a real constraint in this school because we offer such a full program. Despite this we identified in our review that we needed to improve our teaching to better challenge students and their learning. We are concerned about this across the curriculum but it seems to be most evident in science because of how complex some of the curriculum topics are."

Julie's aspirations were congruent with these concerns.

"Personally, I want to assist the school work towards these goals. Many of the teachers are very confident with their science teaching. Some teachers though need support and I would like to support the school in lifting our overall teaching performance. I think the school's goals are similar to the goals I have for myself. I want to be able to assist teachers in becoming better science teachers."

She also believed that she possessed the personal attributes to assist in the achievement of these goals and that the school would support her in working towards these goals.

"This is a supportive school. I know (the principal) *believes in my capabilities and is willing to support the schools and my development. I enjoy teaching science. I enjoy helping my colleagues. I take every opportunity to attend science development opportunities. I might not have all the answers but I want to work towards taking on more of a leadership role…. I can also use the professional development opportunities I attend at* (local university) *as credit towards my degree* (further reference to a pay scale change)…. *The* (school) *board pays for this so that's event better."*

Julie was able to identify that both her personal science-teaching and leadership efficacy and the school's affirmation of her capabilities were protective factors in supporting her trajectory towards becoming a science-teacher leader. She also identified that the opportunity to move towards a pay increase and the fact that the school board was paying for the professional development and university study was an incentive in fulfilling the teacher-leader role. She did not identify risk factors that could be possible impediments to fulfilling this aspiration.

B. Rural School: Wendy's Reflection

Wendy, as well, affirmed that the SCIQ profiles were indicative of where Rural School stood in terms of science program delivery (School Ethos $\overline{X}$ =2.35, Time $\overline{X}$ =2.08, Professional Interest= $\overline{X}$ 1.49).

"ERO identified a serious concern in the way we deliver science at the school. Really, it's the way we don't deliver science. It has a low priority mainly because there are other areas that are of more importance at the primary level. I think we work to address the curriculum but only in the areas we feel the need to. It's just the way it is. None of us are particularly strong or interested in science. I think this reflects in how much time we spend teaching it and the poor resources we have."

Wendy's journal results suggested that her aspirations for her own development were congruent with the setting in which she worked. She also identified that her personal attributes would contribute positively to achieving these goals.

"I know we need to move ahead with science and I don't mind taking on this role. I am very comfortable with teaching science; more than most I'd suppose. I know my science and am very comfortable with the curriculum at this level (referring to Years 1-6). *I work well with the staff, and if anyone is going to move us along I know I can do a good job of this. I know* (the principal) *wants me to just get on with it and she'll support me as necessary. I know I can't be too demanding. I know we'll make progress but I am not sure it will be enough for ERO."*

Despite her expressed journal comments about being comfortable with science, her interview comments indicated reservations about potential risk factors in achieving positive results.

"*I am somewhat anxious about my capabilities. I will work with* (the professional development provider) *but will probably take a back-seat in the process. I don't feel particularly knowledgeable or confident. I can also see my colleagues being low-key* (ambivalent) *about the entire process."*

C. River School: Bronwyn's Reflection

Bronwyn suggested that the profiles were indicative of the current science situation at her school. She affirmed that the lower scores for the environmental factors (School Ethos $\overline{X}$ =2.38, Professional Support $\overline{X}$ =2.38, Resource Adequacy $\overline{X}$ =2.35) reflected school curriculum priorities rather than professional attribute deficiencies (Professional Knowledge $\overline{X}$ =3.12, Professional Interest $\overline{X}$ =3.12, Professional Adequacy $\overline{X}$ =3.78).

"Science isn't an area we pay much attention too. There are some science-related events that occur in the school year that lift its' profile, but, overall, it's not really emphasised…. I think this reflects our school's priorities and time availability rather than our personal abilities."

Bronwyn's aspirations for her own professional development were similar to what she perceived as the school's goals.

"I think for us as a school it's just a matter of devoting more time to science. I don't think we struggle with its delivery; it's about finding the time…. I felt alright about taking on more of a leadership role because I think I have the ability to move us in that direction. I am not sure if I have that much time to devote to this role AND my own growth if I am expected to take on a more prominent role. It's made a lot easier when you know that your colleagues could do a similar job, it's just about taking the time."

Each of the three teachers identified that both their own leadership development and the school's science delivery improvement were likely to be conditional on a variety of personal attribute and environmental factors. Teachers perceived (aside from Wendy's apparent contradictory comments) that their foundational capabilities (e.g., science content knowledge), confidence and personal commitment would contribute to and serve as protective factors in fostering their development. As well, each teacher perceived that several environmental factors would support their development. Collegial support, support from the professional development provider and the school administration's expectation for them to develop were identified as potential protective factors supporting their trajectory towards becoming science teacher-leaders. The teachers also identified

possible risk factors. Time availability and collegial ambivalence to the overall development agenda were suggested to be potential impediments to both the schools and their own development.

Formative Comments from Teacher-Leaders

From late January through to June the three teachers were provided the opportunity to be engaged in a variety of in- and out-of-school opportunities to facilitate their development as science teacher-leaders. These situations included spending extra contact time with the school's science professional development facilitator devoted to planning, assessment and development of science content, curricular, pedagogical and pedagogical content knowledge; attending professional development workshops; identifying and purchasing support materials; meeting with other science teacher-leaders in schools within the region; identifying valuable science-teaching websites; participating in electronic and voice mail contact with the author and working individually and in collaboration with the program facilitator in leading the in-service at their home school. The teachers were each asked to comment on their own development in the context of the school's development process. Since the researcher was overseas at the time, all conversations were completed through electronic mail. The questions guiding the discussion were: (1) Comment on the success of both your personal and the school's development; and (2) What factors do you perceive are contributing to and constraining your development as a teacher-leader?"

A. City School: Julie's Reflection

Julie indicated that the school's development program was successful albeit limited by time constraints. She identified that the school had responded positively to the challenge of working towards improvement in instruction. Equally, they had responded positively to her designated role as a developing science teacher-leader and supported this development in a variety of ways.

"I have been encouraged in my development by (the principal) *and my colleagues, especially* (a senior teacher) *and* (the professional development facilitator). *It's been good to have support close at hand* (referring to the geographical proximity to the facilitator). *I have had responsibilities given to me and this has kept me on my toes. The* (in- and out-of-school professional development) *sessions I've have been invited and encouraged to attend have been really beneficial. I haven't found the expectation for me to take on this role overwhelming because of the support that has come with it. It's also been quite gradual. When I've had to lead a session I know that there is trust and confidence in my capability and I've done what I've been capable of doing. I know I have developed in my knowledge; not just my science knowledge but also in my knowledge of how to teach things and the curriculum…. I've enjoyed having more release time* (from classroom teaching in order to lead school-wide development sessions)*."*

B. Rural School: Wendy's Reflection

Wendy's experiences contrasted significantly with Julie's. She identified that the lack of progress both she and the school had made were due to a variety of factors, both of a personal attribute and environmental nature.

"We just don't seem to be getting anywhere…. The initial school development session we had (at the start of the school year) *was really good, but we just didn't seem to follow through…. I feel that this has had a lot do with me, I'm afraid. I organized the first teacher-only day in February. We were to develop the units of work collectively under my guidance and we haven't made it a priority. I guess I just didn't make it a priority and no one seemed to mind…. I haven't been to the* (provincial) *professional development sessions…. I've had contact with* (the professional development provider) *and he's left it to me to get back to him* (for further professional development and mentoring) *when we're ready…. Maybe if I was more interested or there was more of an expectation* (from the professional development provider and administrative and teaching staff) *I would have followed through….* (The senior management team) *haven't really contributed to making anything happen either and I expected that to happen."*

C. River School: Bronwyn's Reflection

Despite the similarity in school environments, the outcomes after the first two terms of the year for Wendy and Bronwyn were markedly different.

"We've made a lot of progress. We've taken on board science as a priority. The professional development early in the year really got us going. It made my responsibility to science a lot easier by having everyone on board. For us, it's just been priorities. For the most part we enjoy teaching science and giving it a focus has rekindled those interests…. I haven't been alone in attending the professional development sessions (in the nearest city) *and* (the professional development provider) *has worked in well with our intentions…. My colleagues have been a real encouragement; especially those that have been attending the PD sessions with me…. Some of them could be doing a better job than me, but they've made me get on with it."*

All three teachers were able to identify that at this stage of the professional development agenda a variety of personal attribute and environmental factors were either contributing to or impeding both their own and the school's development. Their commitment (or lack of) to the development agenda was a critical factor influencing this process. Similarly, their developing efficacy in carrying out the role of a science teacher-leader was equally significant. None of the teachers identified their professional science capabilities (e.g., science content knowledge, science curriculum knowledge) as factors of significance influencing their development. Although this attribute was not mentioned, it is unlikely that their development would have been successful without an adequate professional science capability. Teachers also identified environmental factors

either contributing or impeding their development. Factors such as the level of collegial support they were receiving; the priority that the school was placing on the development agenda; time availability (including teacher-release time for teacher-leader duties) and the school's expectation for their performance were either risk or protective factors influencing their development.

Culminating Teacher-Leader Reflections

The final discussion with the teacher-leaders occurred in either May, 2004, four months into the following school year. By this stage, all schools were responding to the Ministry of Education's recent introduction of The Arts curriculum and the professional development opportunities this provided nationally. Both City and River school continued to maintain an emphasis on ongoing science development opportunities despite the cessation of funding devoted to external professional development support. The interviews were based on entries teachers had made in their reflection diaries at the end of the professional development agenda. The discussion focused on considering what conditions of their personality and immediate school setting invited, permitted or inhibited their developmental activity.

A. City School: Julie's Reflection

Julie identified that the professional development agenda had fostered the schools and her teacher-leader development. She could identify that the success of the process was a result of personal attribute and environmental factors.

"I think last year's success with science has set an example for us in The Arts. We see the need for working collectively…. Identifying individuals who have the interest and commitment to pursue their own development and that of the schools is really important. There has to be some capability as well; some basic capabilities (in the curriculum area) *like knowledge and general confidence are important. You have to see that the person has some of the capabilities the job requires. We've again identified individuals to take on leadership roles in The Arts and again there is a lot of support in developing their capabilities…. I can see that there is something important about WHO does the leading though. There's certainly something to be said about personality. I don't think you support someone in this role when they don't have good leadership and organizational skills."*

B. Rural School: Wendy's Reflection

Similarly, Wendy was able to identify that Rural School's relative lack of success was also a result of personal attribute and environmental factors. As well, her lack of success was attributable to the interplay between these factors.

"Things did get better – actually they got worse before they got better. We had another professional development session in Term 3 (September) *and that got me going…. Trying to get others going after that though went pretty bad. I was pretty much on my own and* (some staff members) *just didn't want things to get going. I am not sure if it was a reaction to me or if it was just science. I think you can only lead when people want to be lead. Maybe I didn't lead very well. Maybe I left it too late….Maybe if I had more support* (from senior administration)…. *Anyway, in the end we had a couple of good professional development days during the year, but really, not much else happened. I just kind of said, "O.k., that's enough, I'm out of here". I don't think it was just about me…. I can't say I feel much better as a teacher-leader either. I just see myself as a teacher.*

C. River School: Bronwyn's Reflection

Similarly, Bronwyn was able to identify the success of the development process as a result of and the interplay between personal attribute and environmental factors.

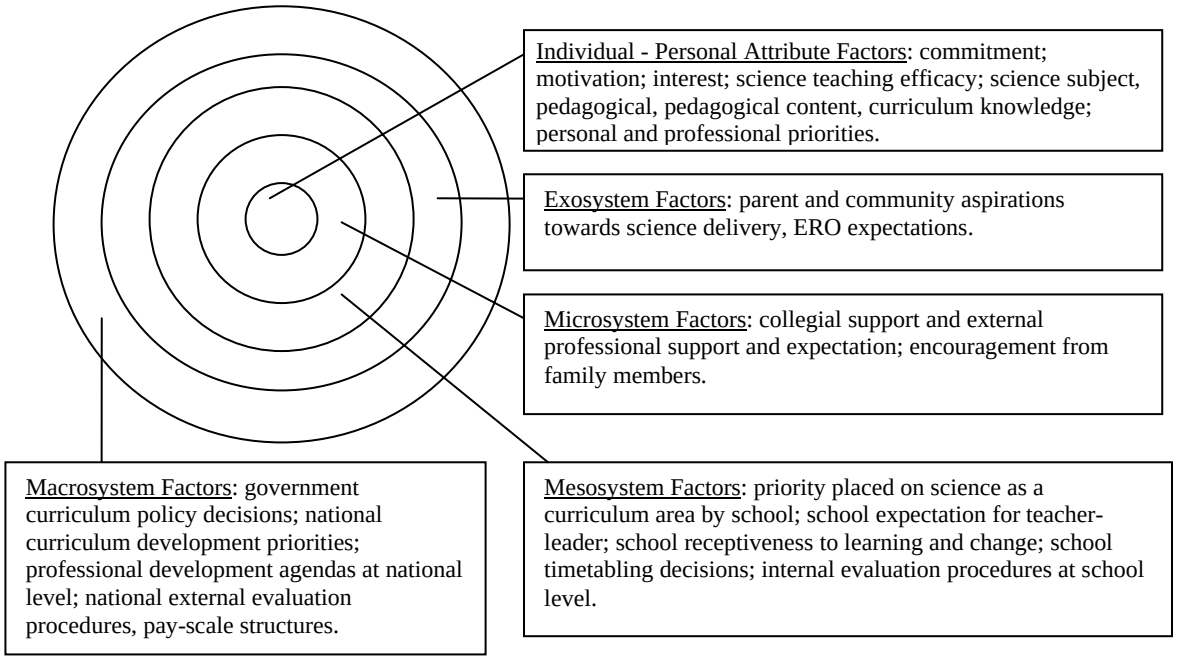
"Last year was a significant year for me professionally. I was given an opportunity to develop (as a science teacher-leader). *I knew I had the competencies to do the job. I really developed in my science teaching confidence…and my skills as a teacher as well…. The opportunity was accompanied by a lot of support from individual people both within* (referring to colleagues and senior administration) *and out of the school* (referring to the professional development opportunities and provider). *I was ready for it professionally. It came at a good time in my career and I was in the right place* (the school professional environment and in my personal life with the support of my husband) *to take on the commitment it required. I can't say enough though about how those that you work with make the difference in this process. We still continue with a science focus…ERO is back next year…I've been told to carry through with what we started* (in terms of science development).

Overall Consideration:

The experiences of these three teacher-leaders provide a context in which the ideas posited by Bronfenbrenner and Rutter can be explored. As previously mentioned, Bronfenbrenner's ecological model requires development to be examined as a joint function of the characteristics of the person and the environment; that is, development is both person and context dependent. Rutter's research in resiliency further extends this understanding of how bio-ecological attributes can influence development by suggesting that some attributes impede development and others contribute to development. Within each of the three situations described in this inquiry, 'risk' and 'protective' factors influenced teacher-leader development (Rutter, 1987). Risk factors can be identified as the personal attribute factors (e.g., poor commitment) or processes in the individual's environment (e.g., teacher and administrative ambivalence) that contributed to negative trajectories in development. Conversely, protective factors were the 'engine' processes possessed by an individual (e.g., positive

self-concept) or in an individual's environment (e.g., an encouraging staff member) that contributed to positive outcomes and consequence in personal development.

Figure 2: *Factors influencing teacher-leader development*



Within the context of this study and as identified by the teacher-leaders themselves, it is apparent that individual personal attribute factors such as professional science knowledge (including curricular, science content, pedagogical and pedagogical); science teaching efficacy; interest and motivation are important determinants in influencing development as a science teacher-leader. Of utmost importance to the development of each of the three teachers was their level of commitment to becoming a teacher-leader. In the case of Julie and Bronwyn, it was a positive dispositional characteristic contributing to their development. Although each of the three teachers was intrinsically interested and perceived to possess foundational capabilities (e.g., science content knowledge, science-teaching efficacy) necessary to becoming a teacher-leader, commitment influenced their decisions to attend professional development sessions; devote the time necessary to ensure they were actively pursuing the development agenda and, ultimately, to persevere when faced with a challenging situation. Commitment and interest were influenced both intrinsically (e.g., interest in the subject and assisting the school) and extrinsically (e.g., pay scale change, obligation to school). Both Julie and Bronwyn experienced a growth in teacher-leader efficacy through positive achievements during the professional development agenda. Conversely, Wendy's lack of

development in teacher-leader efficacy can be attributed to limited positive achievement during the agenda. Initially, she was not strongly committed or motivated to follow through on the professional development agenda, both for her and the school. Later in the year, she became motivated to follow through on the expectations. When she experienced resistance, this motivation dissipated.

The physical, social, and cultural features of the settings in which the teachers worked also strongly influenced their development as science teacher-leaders. Environmental factors such as geographical location, collegial support, encouragement and expectation, time availability and school culture elements such as the priority placed on science were either contributors or impediments to their development. In particular, the innermost structure or microsystem consisting of closely associated school colleagues had a major affect in permitting or inhibiting activity. As Fullan (1991) asserts there is no getting around the primacy of personal contacts. Bronwyn and Julie experienced collegial support and encouragement as a protective factor. For the most part, the lack of collegial and professional support Wendy experienced was a risk factor influencing her professional trajectory. Of further significance to this inquiry and science teacher leadership is the acknowledgement that supporting processes within these overlapping structures were 'engines' for Julie's and Bronwyn's development. Of particular importance were the 'proximal' engines of colleagues, senior administration and professional development facilitators. The developmental processes that occurred within this microsystem were in good part defined and limited by the beliefs and practices of the mesosystem, the school's ethos towards science as a curriculum area. Within the school context the belief systems held by the school staff were largely a reflection of those of the community, the exosystem, in which the school was situated. At City School, the community's expectation for a high priority to be placed on science influenced the decisions made by the teaching staff and, subsequently, the expectation for Julie to be a teacher-leader and to participate in and lead the development process. Similarly, expectation strongly influenced Bronwyn's development. The school, especially her colleagues, expected her to carry through with the designated responsibilities. In contrast, despite Wendy's intrinsic interest in becoming a teacher-leader, her ambivalence to the professional agenda largely reflected the school community's science ethos. She perceived that a lack of clearly defined and consistent expectation contributed to this ambivalence.

The affect of the macrosystem can also be evidenced in this study. As an example, shifts in national curriculum priority contributed to changes in curriculum priority at each of the schools. The

curriculum development agenda set by the Ministry of Education had significantly influenced the shift in priority from science to The Arts in the year following the professional development agenda at each of the three schools. This emphasis limited the number of professional development opportunities available for teacher-leaders and overall publicity associated with science development. This shift in priority was less significant at City and River Schools where there continued to be a commitment to science development. River School's commitment to science development continued to respond to the Education Review Office's expectation that their science delivery would improve. City school continued to set science improvement as a school priority despite the shift in national curricular emphasis. Thus, macrosystem system factors were influencing the mesosystem (school curriculum priorities and expectation) which in turn was influencing the microsystem (teacher time commitment priorities) and, ultimately, the individual (teacher-leader development agenda).

As Bronfenbrenner suggests the factors influencing teacher-leader development were not only person- and context-dependent but also time-dependent. Bronwyn, in particular, recognized that her opportunity to focus and succeed in her development as a teacher-leader was influenced positively by personal attribute dispositions and environmental conditions. As well, her career position in terms of her life-history as a teacher of science was also a contributor to her success.

The factors identified as contributors and impediments identified by the teacher-leaders in this inquiry are illustrated in Figure 2. These factors are represented as systems or spheres of influence according to the structures identified by Bronfenbrenner. Although these are represented as discrete spheres it is apparent from this study that there is a dynamic or interplay among these spheres in that one factor within one sphere can influence significantly factors in other spheres. As well, although certain personal attribute dispositions and environmental conditions appear to foster the teacher-development process, it is unlikely that these dispositions and conditions will always contribute or impede success. As an example, a teacher-leader may still experience developmental success despite being situated in a school culture quite ambivalent or resistant to engaging in a professional development agenda. In this study, the change in national curricular emphasis did not impact significantly on City's and River's curriculum development agenda and the continued expectation for the science teacher-leaders to fulfill their roles in these schools. As well, although

each factor may influence the desired outcome, the findings of this study suggest that some of these factors are more significant than others.

Summary

The experiences of Julie, Wendy and Bronwyn indicate that Bronfenbrenner's bio-ecological model and Rutter's ideas on resiliency can be used as a theoretical paradigm to conceptualize the factors influencing successful development and understand the dynamics among these forces in influencing science teacher-leader development. As asserted by Bronfenbrenner, the process of development is best understood as a joint function of the characteristics of the person and the environment. Factors specific to the individual and their environment contribute to or impede teacher-leader development. The influence of factors as risk or protective factors at the individual, microsytem, mesosystem, exosystem and macrosystem were evident in this study. As well the dynamic among these levels was apparent. Of particular importance as contributors or impediments to teacher-leader development were the personal dispositions of commitment and interest. Equally significant were the influence of proximal environmental conditions such as collegial and professional support and expectation within the microsystem.

As evidenced in the stories of the three teacher-leaders, the theories posited by Bronfenbrenner and Rutter, are likely to provide a critical 'lens' for planning effective professional development programs that include the development of teacher-leaders. Science teacher-leader development needs to be envisaged as a cultural-contextual process influenced by attributes of the individual and the various levels of environment in which they are situated. Clearly, successful science teacher-leadership development must be fostered within a multi-structure perspective. Effective teacher-leader development programs are likely to occur in settings where protective factors are maximized and risk factors are minimized. For those involved in professional development faced with the challenge of working towards improving science delivery including the development of teacher-leaders, successful development is as likely to emanate from giving attention to the potential individual and environmental factors that constrain and contribute to the development process as it is in focusing on the development of the professional capabilities of individual school teachers and teacher-leaders.

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