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THE DEVELOPMENT, VALIDATION AND APPLICATION OF A SCIENCE CURRICULUM DELIVERY EVALUATION QUESTIONNAIRE FOR INDIGENOUS MĀORI SETTINGS

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ABSTRACT *The study described in this paper examines the procedures used in the identification of the broad and complex factors influencing science curriculum delivery in predominantly Māori settings where the teaching of science, in particular Pūtaiao i Roto i te Marautanga o Aotearoa, is the responsibility of non-specialist science teachers and the teaching of science advocates an orientation to contemporary science in the context of Te Ao Māori, an indigenous epistemology. Furthermore, it describes the processes involved in the development and validation of an evaluation instrument, the Science Delivery Evaluation Instrument for Māori Settings (SDEIMS), used to identify and help kura (Māori schools) in addressing factors influencing science program delivery. The study begins by exploring the themes generated from a qualitative study pertaining to the phenomenon of science delivery in eight kura that encourage science teaching from or with reference to a perspective of Te Ao Māori in the language medium of Te Reo Māori. These themes are explored through the critical lenses of Kaupapa Māori theory and Bronfenbrenner's bio-ecological theory. Subsequent to this, quantitative procedures used to develop and validate the SDEIMS are presented. Finally, practical applications of the SDEIMS as a part of an ongoing initiative are also discussed.*

KEYWORDS

Pūtaiao i Roto i te Marautanga o Aotearoa, Kaupapa Māori theory, Bronfenbrenner's bio-ecological theory.

INTRODUCTION

Science is acknowledged as an important part of every child's education, yet there is much evidence to suggest that primary and middle years (Kindergarten to Grade Eight) science education in many countries, including New Zealand, is in a perilous state (Lewthwaite, 2001; Mulholland & Wallace, 1996). This situation is clearly more acute in indigenous settings where local communities aspire to provide their children with science experiences that combine the views of both Western science and indigenous epistemology. As an example, in Aoteoroa-New Zealand in some Te Reo settings science is not only expected to be in the medium of Te Reo (the language of Māori, the indigenous people of Aoteoroa-New Zealand) but also expected to be taught from the perspective of or with reference to Te Ao Māori (Māori world view) (Wood & Lewthwaite, 2008). Fullan (1993) asserts that curriculum interventions, such as the implementation of *Science in the New Zealand Curriculum* (Ministry of Education, 1993) and *Pūtaiao i Roto i te Marautanga o Aotearoa*[i] (Ministry of Education, 1996), both of which are applicable to Te Reo settings and a combined world view, tend to leave the basic policies and practices of schools unchanged. International efforts, including those in indigenous settings where a dual perspective may be desired, indicate that although the intentions of primary science curriculum initiatives have been admirable, the outcomes of these efforts have primarily been limited to increased teacher awareness and not teacher and instructional change (Harlen, 1997). In brief, intended science curricula are often far removed from what is actually the enacted curricula in schools. The first author's research within New Zealand would affirm such an assertion (Lewthwaite, 2001; Lewthwaite & Fisher, 2004, 2005).

Stewart and Prebble (1985) suggest that effective curriculum implementation initiatives come from a systematic, sustained effort at changing learning conditions in the classroom and other internal conditions within the school and conditions external to the school. Understanding the context in which change is to occur is at the heart of successful school curriculum implementation (Stewart & Prebble, 1983). This understanding is established through the gathering of high-quality information that provides members of the school community insight into the forces at work within the school and within society as a whole. In turn, this information becomes the foundation from which discussion, reflection and deliberate focused change can begin (Stewart & Prebble, 1983). Because of the role this foundational data can have in informing strategic school development including curriculum delivery, the diagnosis or systematic assessment of the school environment is seen as an essential means by which the forces impeding or contributing to curriculum implementation in a school can be identified and addressed.

Stewart and Prebble (1983) describe a variety of strategies for systematic data gathering to foster school, including curriculum, development. One of these strategies is the use of validated instruments. When data collected from the instrument application are coupled with staff discussion, they provide a foundation for increasing collective knowledge and understanding of organizational procedures and problems (Stewart & Prebble, 1985). As an example, the *Science Curriculum Implementation Questionnaire* (SCIQ) has been used in over 300 New Zealand and international mainstream schools and has provided the statistical premise for many of the schools and their development and associated research papers (Lewthwaite & Fisher, 2004, 2005). Despite its widespread use, its development and application have been specific to mainstream schools where a dual epistemological perspective is not mandated.

This study focuses on the methodologies and outcomes of studies pertaining to the identification of the factors influencing primary science curriculum delivery within the context of Te Reo Māori medium settings where both traditional indigenous Te Ao Māori and Western science perspectives are required or suggested. Furthermore, the paper outlines the procedures used in the development of a standardized evaluation instrument, the *Science Delivery Evaluation Instrument for Māori Settings*, which can be used by a school and its community members to identify factors influencing science delivery at the school and classroom level within Indigenous Māori environments.

The research sequence in this study involved several data collection stages divided into two phases. The overarching aim of the first phase was to obtain information that could be analyzed so that the factors influencing science curriculum implementation in Te Reo Māori medium settings could be understood (Bell, 1992). The methods and results of this qualitative segment of the research exercise are presented in full in a further article (Wood & Lewthwaite, 2008) and are not addressed in detail in this paper. The second stage of the study associated with the development and validation of the *Science Delivery Evaluation Instrument for Māori Settings* uses primarily quantitative methodologies associated with pattern identification and statistical analysis. These processes, used in the instrument development and validation, are presented in detail in this paper.

LITERATURE REVIEW: THE DILEMMA OF PRIMARY SCIENCE EDUCATION IN MAINSTREAM AND ABORIGINAL SETTINGS

Although significant attention to and improvement in the delivery of science programs at the elementary and middle-years levels (Year 1 to Year 8) are recognized in some nations over the past two decades, there is continued acknowledgement of the complex amalgam of factors impeding effective science delivery at this level in many educational jurisdictions including Aotearoa-New Zealand (Lewthwaite, 2001). Teacher personal attributes or intrinsic factors such as science teaching self-efficacy, professional science knowledge and science teaching interest and motivation are critical dimensions in the delivery of science programs (Harlen, 1997). As well, extrinsic or environmental factors are identified equally as critical elements to the effective delivery of science programs in elementary schools (Lewthwaite, 2001; Lewthwaite & Fisher, 2004, 2005). This commonly cited list of environmental factors includes more salient features such as time constraints and resource inadequacy associated with limited equipment, space and facilities. Less commonly cited factors such as poor administrative support and the overall low priority placed on science as a curriculum area both within the school and nationally by government policy are also identified as further critical agents impeding science delivery nationally and internationally (Lewthwaite & Fisher, 2004, 2005). Because of the many complex interrelated and difficult-to-address factors impeding science delivery, it is not surprising that some authors regard science education, especially from Kindergarten to Grade 6, to be in a perilous state (Mulholland & Wallace, 1996).

Compounding the problems of effective science program delivery in indigenous, including Māori communities are more severe epistemological issues often cited in the literature. As an example, school science improvement literature has been criticized for universalizing schools and students, paying insufficient attention to context, especially in terms of racial, class and gender differences (Harlen, 1997). Science curricula, in particular, tend to endorse a Western science paradigm that largely ignores indigenous epistemologies and aspirations (McKinley, 2000). As suggested by Ezeife (2003), science instruction often fails to give priority to harmonizing the science students are learning with their life-world culture, including their native language and culturally appropriate learning strategies. As purported by McKinley, the intentions of mandated science curricula do not adequately ground the priorities of indigenous communities as they are largely expressions of the dominant, mainstream culture. By so doing, such curricula fail to acknowledge and override local indigenous communities and their knowledge, values and beliefs as thoughtful and purposeful cultures. In the authors' view, McKinley's comments are deeply rooted in her own experiences in New Zealand, where the dominance of Pākehā (non-Māori) and hegemonic structures such as school curricula have perpetuated the unequal power relations that exist within Aotearoa-New Zealand and are evidenced in the paternalistic nature of school curricula.

Despite this experience, McKinley has been instrumental in her efforts within the education community in New Zealand in collaboratively fostering a parallel curriculum for the New Zealand indigenous community that explicitly acknowledges Māori communities and their knowledge, values and beliefs as a thoughtful and purposeful culture. *Pūtaiao i Roto i te Marautanga o Aotearoa* (Ministry of Education, 1996) is the foundation science curriculum document for Māori medium schools (kura) in Aotearoa-New Zealand. *Pūtaiao* parallels *Science in the New Zealand Curriculum* (Ministry of Education, 1993), the curriculum document for mainstream and English-speaking classrooms. Currently 87 percent of Māori receive their schooling in the medium of English. *Science in the New Zealand Curriculum* explicitly encourages mainstream teachers to make science more accessible to Māori students by, among other things, acknowledging tikanga Māori (culture, beliefs, values) and valuing the use of Māori language and experiences of Māori students. *Pūtaiao* has been developed as a parallel document for kura in which the language of instruction is Te Reo Māori. Although the development of this curriculum and its rationale has been subject to some discontent by Māori (McKinley, 1996) as it attempts to fit a science curriculum for Māori into the framework of the science curriculum for English-medium schools, the curriculum is believed by the curriculum development team to be grounded in Te Ao Māori (Māori epistemology).

Pūtaiao in its most simplistic form endorses the teaching of contemporary science from the perspective of or at least with reference to a Māori worldview. There are clearly differences in epistemological perspectives between the *Science in the New Zealand Curriculum Document* (SINZC) and *Pūtaiao i Roto i Te Marautanga o Aotearoa* document. Within both documents is a strand that focuses on Making Sense of the Living World**.** The first four overall achievement aims for this particular strand are the same in both documents. However, within the *Pūtaiao* document there are two further achievement aims that are clear reflections of how a Māori perspective and understanding would permeate this learning strand. Listed below is one of these extra achievement aims with its translation.

- Tūhura i te whakapapa Pūtaiao-ā-nuku o Papatūānuku kia mārama ki tōna tawhito me ōna hurihanga maha.
- Investigate the natural history of Papatūānuku (earth mother) in order to understand her age and her many changes through various forces.

It is how this achievement aim is approached by Māori that provides a unique Māori way of understanding the living world. First, the planet is not viewed as simply a planet, where an empirical approach to examining the processes such as tectonic activity that change the landscape of Aotearoa and are substantiated through evidence from observation and measurement. A Māori approach to understanding and making sense of the living world includes this contemporary science reference but takes a much more holistic and spiritual approach to viewing the planet, and views planet earth as having a spiritual life force personified by Māori as Papatūānuku, the earth mother. This is just one example of a Māori approach to understanding and making sense of the living world, where in Māori eyes everything does in fact have a living essence and being.

The introduction of *Pūtaiao* is consistent with McKinley's call for mandated curricula in Aboriginal[ii] settings that take greater awareness of indigenous knowledge systems and language (McKinley, 2000). It is obvious that, although such efforts are admirable, they magnify the complexity of factors mitigating effective science delivery. Lewthwaite and McMillan (2007) identified in their analyses of practices in selected Nunavut schools in northern Canada that for most teachers (both Inuit and non-Inuit) teaching to the intent of an Inuit epistemology is beyond their ability as it deals with traditional Inuit knowledge. This is consistent with Aikenhead and Otsuji's (2000) identification that the role of teacher as culture broker is complex because most curriculum developers and teachers of science are of the mainstream culture and have limited knowledge of Aboriginal knowledge systems and culturally appropriate pedagogies. The first author extends this limitation by suggesting that despite teachers' motivation to promote instruction in a manner that honours Māori epistemology, even some indigenous Māori teachers have difficulty in teaching science from a Māori perspective because of their insufficient epistemological base. Clearly, if teachers cite a limited professional science knowledge base for teaching in mainstream schools, this knowledge base is even less adequate for teaching in settings where the teaching of science calls for teachers to help students move back and forth between their indigenous culture and the culture of contemporary science.

THEORETICAL FRAMEWORKS FOR THE STUDY

Two theoretical frameworks inform this study: Kaupapa Māori theory and Bronfenbrenner's bio-ecological model. Both are used as critical lenses in understanding the processes influencing science program delivery.

Kaupapa Māori theory

The second author, a New Zealand Māori, uses Kaupapa Māori theory as a lens for recognizing and understanding the complexity of the factors impacting on science program delivery. A basic foundation of the word *Kaupapa* is "ground rules, customs and the right way of doing things" (Pihama, Smith, Taki & Lee, 2004). Smith (1997) describes it as an educational strategy and a transformative practice that evolved out of Māori communities as a deliberate means to comprehend, resist, and transform crises related to dual concerns of schooling underachievement of Māori students and the ongoing erosion of Māori language, knowledge, and culture, as a result of colonization. Pihama et al. (2004) add that Kaupapa Māori theory derives from distinctive cultural epistemological and metaphysical foundations, and is a conceptualization of Māori knowledge. Kaupapa Māori theory stems from a Māori worldview, is based on Māori epistemology, and incorporates Māori concepts, knowledge, skills, experiences, attitudes, processes, practices, customs, language, values, and beliefs (Bevan-Brown, 1998).

A number of key principles are integral to Kaupapa Māori theory. The principles are clearly evidenced as underpinning Māori medium educational settings. According to Smith (1997), the principles are common to transformative Māori educational developments and school initiatives. These principles are considered to be the crucial elements required for, and commonly evidenced in, successful change.

1. Tino Rangatiratanga – The Self-Determination Principle.
   This principle addresses the need for sovereignty, independence, autonomy, and self-determination reflected in Māori being in charge of the key decision making as reflected in school administration and cultural aspirations.

2. Taonga Tuku Iho – The Cultural Aspirations Principle
   This principle asserts a position that to be Māori is both valid and legitimate, and all that is Māori must not be taken for granted. The transmission of Māori knowledge and ngā taonga i tuku iho (those treasures handed down to us by our tupuna – ancestors) are all seen as being critical in curriculum development and pedagogy for Māori education.

3. Ako Māori – The Culturally Preferred Pedagogy Principle
   This principle promotes teaching and learning that is more aligned and unique to Tikanga Māori. In the wake of educational underachievement of Māori, it becomes essential that Māori are able to choose their own culturally preferred pedagogies that are more closely connected with the background of students' needs.

4. Kia Piki Ake i Ngā Raruraru o Te Kainga – The Socio-Economic Mediation Principle
   This principle acknowledges that despite any socio-economic disadvantages or difficulties that Māori may be experiencing, Kaupapa Māori practices and values work to ensure that a collective responsibility involving the whole community will come to the foreground in order to ensure the overall wellbeing of the whānau. The principle advocates drawing on cultural capital to overcome obstacles to see the realization of collective goals.

5. Whānau – The Extended Family Structure Principle
   Like tino rangatiratanga, whānau is at the heart of Kaupapa Māori theory. The

cultural practices, values, and customs, which are organized around whānau and the need for collective responsibility, are a necessary part of Māori wellbeing and educational achievement. The word *whānau* also describes a unity of purpose and is sometimes termed as "kaupapa whānau" meaning a metaphorical whānau, developed around achieving a particular aim or goal (Pihama et al., 2004).

6. Kaupapa – The Collective Philosophy Principle
   This principle ensures that Māori centered initiatives within education, and in fact all fields, are held together by a collective commitment and vision. It ensures that such initiatives are connected with Māori aspirations to political, social, economic and cultural wellbeing. In Māori education, an example of this collective vision is the "Te Aho Matua" document.

Although these principles are not seen to be definitive (Smith, 1997), they are envisaged as the keys for contributing to success in Māori aspirations for their children's education. Although much of the material in regards to Kaupapa Māori theory is related to education and social justice, it must be stressed that Kaupapa Māori theory is not bound to only one sector. It is relevant to all aspects of Māori social development (Pihama et al., 2004).

Bronfenbrenner's Bio-ecological Model

The first author, a New Zealand Pākehā (European), uses Bronfenbrenner's bio-ecological model as a lens for analysis in recognizing and understanding the complexity of the factors impacting science program delivery. This author believes the professional science knowledge base of individual teachers in Te Reo settings is likely to be one and potentially not the most significant of a multiplicity of factors that impact on a school community's aspiration towards the delivery of science that honours Māori epistemology. Understanding how other personal attribute factors and multi-system environmental factors influence successful science delivery and development that harmonize traditional and contemporary epistemology is likely to be best understood by considering cultural-contextual theories of development. Bronfenbrenner's (1979) bio-ecological theory of development posits that development is a joint function of the person and all levels of his or her environment. The former includes personal attribute factors that are both biological and psychological (e.g., genetic heritage and personality). As suggested by other studies (for example, by the first author), teacher personal attribute factors such as professional science knowledge, including both traditional and contemporary science knowledge, science teaching efficacy and interest and motivation in teaching science are likely to be important determinants in effecting the delivery of science in a manner that honours Māori epistemology. The latter encompasses the physical, social, and cultural features of immediate settings in which human beings live (e.g., family and school). 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). The innermost structure consisting of a teacher's students, colleagues and possibly friends and family, the microsytem, is the immediate proximal setting the person directly interacts with that invites, permits or inhibits activity. It is likely that if students are very responsive to using or learning their traditional knowledge, a teacher is more likely to make reference to it in her teaching. 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. Thus, the school's belief systems and values may strongly impact on the expectations endorsed by members of a microsytem. As an example, within the school context the belief systems held by senior teachers, the principal and school administration, including the Board of Trustees, concerning the importance of delivering a science program in a manner that honours Māori epistemology are likely to strongly influence the school's ethos for such an initiative. The third structure, the exosystem, 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 whānau's (school community families) aspirations for science and the support provided by community members are likely to impinge on school-based policy decision making and implementation. 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, the Ministry of Education's inclusion policies, curriculum agendas and teacher education protocols, as well as external reviews provided by the Education Review Office (1995), are likely to influence the school's response to science as a curriculum area.

The ideas posited by Kaupapa Māori theory and Bronfenbrenner would suggest that understanding the processes that impact on science delivery that honours Te Ao Māori is best investigated within a research inquiry where one is able to examine the personal attribute and environmental processes at the classroom, school and community and, possibly, national level and the interplay among the processes that have bearing on teachers and school communities in the delivery of science. Such was the nature of the first phase of this study.

CONTEXT OF THE STUDY

This research and development project is based in eight predominantly Māori Year One to Six (and in some cases Year Eight) school (kura) communities in the central region of the North Island of Aotearoa-New Zealand. The eight communities were identified through Ministry of Education data that identified, among other demographic data, schools of high Māori enrolment within this geographical area and instruction in Te Reo Māori (Māori language medium instruction). Ministry of Education data identify that currently 13.1% of Māori in Years One to Eight receive (at least some of their) school instruction in Te Reo.

Since it is teachers that are charged with the delivery of curricula, in this study's case *Science in the New Zealand Curriculum* or *Pūtaiao i Roto i te Marautanga o Aotearoa* or at least learning experiences that reflect a Māori perspective and understanding, teacher and school community voice were particularly important in identifying factors influencing the delivery of *Pūtaiao* in a manner that was consistent with Te Ao Māori. Consequently, representative teachers and school members from each kura were 'interviewed' either as individuals or groups, often in Māori, to ascertain their perceptions of factors influencing delivery. As suggested by Bishop (1996) the formal interview was more of a conversation, the informal interview as chat and the need for collaboration between researcher and researched in constructing the final story as evidenced in the vignettes that follow.

Typically both authors participated in the conversations. The conversations included several elements. First, people were asked to consider the philosophical premise of *Pūtaiao* and to indicate whether their science teaching aspirations were congruent with the intent of the curriculum. Second, they were asked to provide examples of their own teaching practice that they believed were congruent with the curriculum's intention. If their personal science teaching aspiration was inconsistent with the intent of *Pūtaiao* they were asked to provide an example of teaching practice that elucidated this difference. Third, they were asked to elaborate on factors that had made these practices a reality. Further to this, school administrators were interviewed to gather parallel perceptions of factors that they perceived had influenced the development of the school overall in ways that honoured Te Ao Māori. In most cases the administrators were Māori. These sources of information provided sufficient information to identify through the lenses of Kaupapa Māori theory and Bronfenbrenner's bio-ecological model consistency in the information collected.

THEMES IDENTIFIED FROM PHASE ONE

The data collected in the data collection stages of the initial qualitative phase of the study indicated that the effectiveness of science program delivery within Te Reo Māori settings was indeed strongly influenced by a variety of teacher personal attribute and environmental factors (Wood & Lewthwaite, 2008). We provide here an abbreviated account of these factors. Kura members were able to identify that at the heart of their achievement of *Pūtaiao* implementation was the principle of Tino Rangatiratanga, the Self-determination Principle. They themselves had to take meaningful control over achieving their aspirations. They themselves needed to identify their *Pūtaiao* aspirations (The Cultural Aspirations Principle of Taonga Tuku Iho).

Their professional science adequacy; professional science attitude and interest towards science and the teaching of science; and professional science knowledge of teachers were identified as critical and pivotal factors perceived by teachers to be either contributing to or impeding science program delivery. The professional science knowledge required by teachers was identified as multi-dimensional in nature. Teachers identified the need for not only knowledge of science content, but also less salient dimensions of science knowledge such as pedagogical content knowledge and knowledge of instructional skills for supporting the learning of science in Te Reo and in ways specific to Māori learners (the Principle of Ako Māori: the Culturally Preferred Pedagogy Principle). Teachers commonly suggested students' limited Te Reo base made science teaching difficult. This limited Te Reo base also influenced teachers' decisions about curriculum priorities, often sidelining science within the overall school program. Of critical importance to teachers was their knowledge of Te Ao Māori and, furthermore, ways in which to integrate Te Ao Māori with contemporary science knowledge as advocated by *Pūtaiao*. Equally, the process of curriculum delivery was mitigated or inhibited by several other factors, many of these associated with the physical and psycho-social dimensions of the school environment.

Although teachers may be the critical agents in the curriculum implementation process, these initial studies affirmed that teacher professional adequacy, knowledge, and interest were but one dimension in the complex matrix of factors that influence primary science delivery. Of particular significance was the role that school based curriculum leadership provided by the principal especially; external professional and most importantly whānau support; and, in general, school culture, had in influencing science curriculum implementation and program delivery. Teachers and parents commonly cited that science instruction was secondary to the development of Te Reo language and cultural proficiency and, consequently, were reluctant to see more priority given to science. Curriculum focused leadership and a school culture that advocated collaborative curriculum development in science in conjunction with whānau to enhance educational opportunities for students, were factors frequently cited as strongly influencing science program delivery negatively. These aspects are at the heart of the principles of whānau (the Extended Family Structure Principle) and Kaupapa (the Collective Philosophy Principle). Teachers also recognized that the external evaluations provided by the Education Review Office (ERO) positively influenced science teaching by ensuring it was taught within the overall school program. Similarly, ERO positively influenced the teaching of science from a Te Ao Māori perspective.

Overall, the case study analyses accompanied by the data collected from the teacher, principal and school community interviews and literature review assisted in the identification of many factors that influenced science program delivery in Te Reo Māori medium settings. These data became the foundation for the development of an instrument to systematically evaluate factors influencing science curriculum implementation in Te Reo settings, the focus of the next phase of this study.

PHASE TWO

Each of the factors influencing science program delivery identified in the Phase One studies was placed on an 'Instrument Items' list. In all, 184 items identified in the Phase One study were developed as items to be considered for the instrument. The list was not categorized or ranked; it simply listed all the specific factors that had surfaced during the Phase One studies. The next step in the development of the SDEIMS item list was to eliminate some of the repetitive statements. Repeating items that were identical or differed in only a word or two were eliminated from the clusters. This procedure reduced the number of items on the Item List to 124 items. As the factors influencing implementation were identified, they were modified so that they would be appropriate for a teacher-response questionnaire. That is, a teacher would be able to answer or respond to the statement in the context of his or her classroom or school environment. As an example, one teacher had mentioned in the case study interviews that:

> The Te Reo background of students and their cultural background are not very strong (in the bilingual unit). This has an influence on how and what you teach. I place a lot of emphasis on language development and this doesn't serve science well. You just give more priority to Te Reo. *Year 4 teacher*

In order to change it into an item appropriate to the intent of the questionnaire it was modified to:

> Item 94: *I do not put priority on the teaching of science.*

and:

> Item 95: *The focus that the kura places on Te Reo language development negatively influences the priority placed on science.*

FOCUS GROUP CONSULTATION

It was anticipated that many of the items would 'repeat' themselves or, at least, belong to general groupings or categories of factors known to influence science program delivery. The identification of these groupings and classification of items was seen as the next critical stage of the instrument development. For these reasons a focus group consisting of four people, each representing a different sector of the primary science education community, was established. The focus group included a Māori primary science teacher educator, a primary science school advisor, a senior teacher in Te Reo Māori, and a researcher in instrument design. The items were easily identified as being resident within one of nine general clusters. Several of these categories (for example resource adequacy; provision/availability of professional support; staff interest; staff time availability; administrative leadership and commitment) were those identified by Fullan (1992, 2002). Most of these categories were primarily school culture or environmental attributes and failed to address the personal attributes of professional knowledge and professional adequacy/confidence consistently identified in the Phase One studies. Although the factors influencing science program delivery in mainstream schools has been well-explored in New Zealand (for example Lewthwaite, 2001), some factors influencing science delivery were specific to the Te Reo setting (Wood & Lewthwaite, 2008). These included the Te Reo - language capability of students; the pedagogical capabilities of teachers teaching science to students with poorly developed Te Reo capabilities; the role of whānau in supporting the teaching of science from a Te Ao Māori perspective; and the capabilities of teachers in being able to not only teach from a Te Ao Māori perspective but to teach this in a 'two-way' manner integrating a Western science and Te Ao Māori perspective as advocated by both *Pūtaiao i Roto i te Marautanga o Aotearoa* and *Science in the New Zealand Curriculum* in Te Reo medium schools.

DEVELOPMENT OF THE INITIAL INSTRUMENT

Once the items were sorted and ranked, averages of the item rankings were calculated for each of the nine categories. Although the authors scrutinized this rank order using their own professional judgment, they were confident that the average rank order, as it existed, represented a hierarchy of items that were representative of the major factors influencing science curriculum delivery. The 88-item SDEIMS in its initial form thus contained nine, nine- or ten-item scales.

VALIDATION OF THE SDEIMS

In order to validate the initial instrument, a large participation of kura and teachers was required. As well, the settings for the validation process ideally needed to include the four Te Reo settings previously identified. The questionnaire, in Te Reo Māori, was distributed to 27 kura in Aotearoa-New Zealand which had high Māori roles and provided learning opportunities in Te Reo for students in Years One to Six or Eight. The 27 kura consisted of 3 Kura Kauapapa Māori, one Kura-a-rohe and 23 kura that offered either or both bilingual or rumaki reo learning opportunities for their students. It was predicted that these 27 schools would provide a response from at least 100 teachers. A request was made for the questionnaire to be completed by all teachers that taught science in Te Reo at these kura. In all, 82 teachers from 19 kura completed the 88-item questionnaire.

Statistical analysis on these 82 questionnaires was able to then be performed to ensure that the *Science Delivery Evaluation Instrument for Māori Settings* would measure what it claims to and that there were no logical errors in drawing conclusions from the collected data (Cook & Campbell, 1979). To identify the underlying dimensions of the 88-item SDEIMS, a principal-components analysis was performed. Although the focus group had placed items in logical categories, the statistical analysis would determine whether these groupings were statistically accurate. Given the exploratory purpose of this analysis, a promax oblique rotation of the factor loadings was performed to assess the degree to which the dimensions or categories are associated with one another.

Out of the 88 items in the initial version of the SDEIMS, 85 items reflected 8 dimensions that collectively accounted for 81% of the total variance. The largest factor, accounting for approximately 23% of the total variance was Community and Professional Support and Opportunity, which included items such as “I am supported in my effort to teach science from the perspective of Te Ao Māori” and “The school whānau supports me in teaching of science in a way that integrates science with a Māori perspective”. The second factor, Professional Adequacy, included items such as “I feel prepared to teach science from the perspective of Māori values, beliefs and knowledge (Te Ao Māori)” and “I can confidently teach science with reference to Te Ao Māori”. Professional Knowledge specifically focusing on knowledge of the science and tikanga was the third dimension based on items like “I have a good knowledge of the both the contemporary science and traditional knowledge we want students to learn” and “I have a good knowledge of Māori culture as it relates to the teaching of science”. The fourth factor contained items specific to a type of pedagogical content knowledge that pertained to Integrating Te Ao Māori and Contemporary Science Knowledge and included items such as "I have a good knowledge of ways to teach science that integrate a contemporary science with a Te Ao Māori perspective". In the next factor items from two scales from the initial 88-item instrument were merged. These items pertained to Time and Priority for Teaching Science including an item such as "I have the time to teach science from the perspective Te Ao Māori" and "I am committed to teaching science from the perspective of Te Ao Māori culture and values". The sixth factor focused on Kura Priority for Science as a Curriculum Area with items like "The school community places a strong emphasis on learning science from the perspective of Te Ao Māori" and "There is leadership within the school for the teaching of curricula like science from a Māori perspective". The seventh factor pertained to School Curriculum Organization including curriculum planning. Included in this scale are: "The school is well-organised in terms of knowing what we are to teach and when" and "The school has a formalized plan for what science topics are to be taught each year level". The final scale included items pertained to Pedagogical Capability for Fostering Capability in Learning. This scale included items such as "I have the skills to teach science from the perspective Te Ao Māori" and "I have a good knowledge of the strategies that are beneficial for helping students learn science". Again, this factor merged two of the initial instrument scales, including factors related to teacher awareness of student language background and interest in science.

The correlations between the factors are listed in Table 1. Overall, it appears that while a few factors appear to be moderately associated with one another, none of the correlations were strong enough to suggest that any two factors could be considered as a single construct allowing for scales to be merged. The strongest relationship between factors was found with Science Knowledge and Community and Professional Support and Opportunity (r = .40). This positive statistical association may reflect the tendency of teachers to perceive themselves as knowledgeable because of the support they receive from advisors including whānau. A further high positive correlation (r = .39) also exists between Community and Professional Support and Opportunity, and Kura Priority Placed Upon Science as a Curriculum Area. This is a very positive indicator that where there is priority on science as a curriculum area in being taught from a Te Ao Māori orientation there is also school community support. As might be expected, there are positive relationships among all three of the teacher personal attribute relationship scales (Professional Knowledge, Professional Adequacy and Pedagogical Capability for Fostering Capability in Learning). This association implies, for example, that as teachers report a greater level of interest and knowledge of science, they also feel more confident about their ability to actually teach science and perceive they possess the pedagogical capability necessary to teach in a 'two-way' environment. It is noteworthy that the highest positive correlation (r = .38) among the personal attribute scales is between Professional Adequacy and Pedagogical Capability for Fostering Capability in Learning. Again, although there is a relatively high correlation it is not so high that we would suggest these scales should be merged.

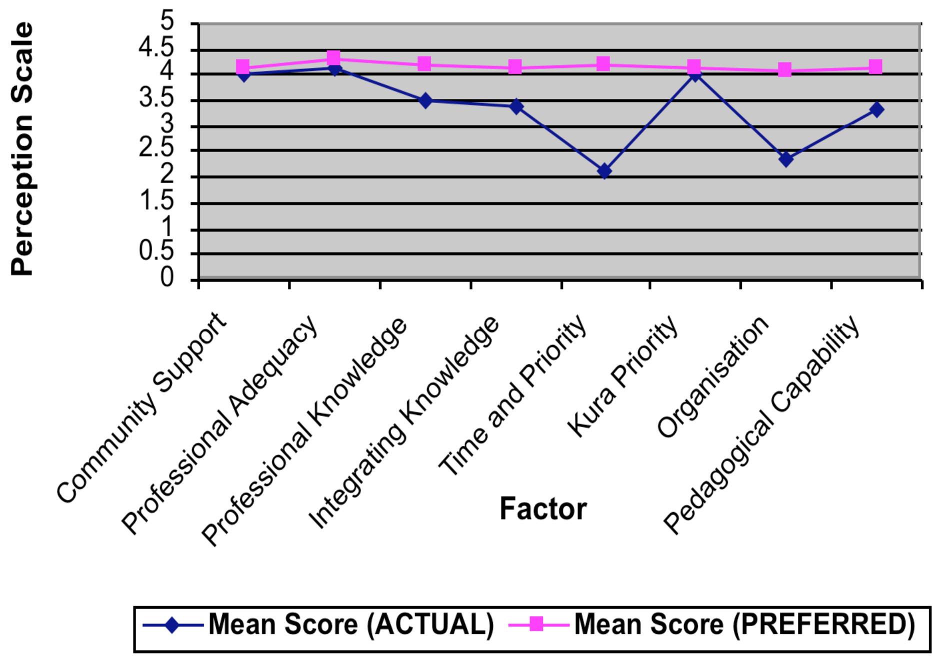
Table 1. Correlations Among Dimensions of SDEIMS

	1 Community and Professional Support and Opportunity	2 Professional Adequacy	3 Professional Knowledge	4 Integrating Te Ao Māori and Science Knowledge	5 Time and Priority for Teaching Science	6 Kura Priority for Science	7 School Curriculum Organization	8 Pedagogical Capability for Fostering Learning
1	1.00	.28	.40	.13	-.11	.39	-.06	.21
2	.28	1.00	.21	.09	-.10	.23	.00	.38
3	.40	.21	1.00	.26	.18	.19	.05	.24
4	.13	.09	.26	1.00	.22	.24	.00	.21
5	-.11	-.10	.18	.22	1.00	-.27	.14	.32
6	.39	.23	.19	.24	-.27	1.00	.15	.10
7	-.06	.00	.05	.00	.14	.15	1.00	-.02
8.	.21	.38	.24	.21	-.02	.10	-.02	1.00

These eight dimensions were in turn used as the scales to be included in the *Science Delivery Evaluation Instrument for Māori Settings*. In order to keep the instrument economical, the first four items with the highest factor loadings within each scale were used as the items for the eight scales. This ultimately brought the instrument to 32 items. The eight scales have been developed with the intent of gauging teachers' perceptions on a 1 (Strongly Disagree) to 5 (Strongly Agree) scale in areas that are identified as major impediments to science program delivery in Te Reo settings where the teaching of science is expected to be from or with reference to Te Ao Māori. In all, the instrument contains eight scales and a total of 32 items and is presented in both Te Reo and English (see Appendix for Te Reo version). Similar to the *Science Curriculum Implementation Questionnaire* (Lewthwaite, 2001) a further thirty-two item instrument was developed (not included in this paper) which states each of the thirty-two items of the SDEIMS as preferred statements (i.e., Preferred SDEIMS). As an example, the item "There is leadership within the school for the teaching of curricula like science from a Māori perspective" is stated as "There would be leadership within the school for the teaching of curricula like science from a Māori perspective". Both instruments (i.e., Actual and Preferred) when answered by teachers not only give an indication of where teachers and schools are perceived to be, but also give an indication of where teachers would prefer to be in science program delivery.

By kura request, the Te Reo version of the SDEIMS in both its Actual and Preferred form was applied in one of the case study schools. The school is characterized as having confident teachers in Te Reo and Te Ao Māori. As well, it is perceived by teachers that the school whānau and principal are very supportive and place significant challenges on teachers to not compromise on the learning opportunities that emphasize a dual learning perspective provided for students. Five teachers with responsibility for the teaching of science in Te Reo between Year One to Eight completed the instrument. Although mean and standard deviation results for each scale can be determined, just mean scores are presented in Figure 1. Factor means for each scale were mainly above 3 indicating a positive perception response. The first author believes that the scores above 4 are exceptionally high for New Zealand schools where mean values for science using the SCIQ rarely are above 3. Considering the outcomes of the qualitative studies conducted in the case study schools (Wood & Lewthwaite, 2008), it is not surprising that most scales of the Actual form were positive with lower standard deviations indicating consistency among teachers that they see most of these factors as contributors rather than constraints to science program delivery. The lower values pertaining to the priority placed on science as a curriculum area and time availability are again typical of many New Zealand schools (Lewthwaite, 2001).

Figure 1. Actual & Preferred SDEIMS Comparison



SUMMARY

The purpose of this paper has been to outline the procedures involved in the development, validation and refining of the *Science Delivery Evaluation Instrument for Māori Settings.* Applications of the SDEIMS within case study schools are encouraging its usefulness as a manageable, evaluation tool for identifying intrinsic and extrinsic factors influencing science program delivery in settings where science instruction is in Te Reo and expected to honour a Māori perspective. In these settings each of the schools (kura) endeavor to achieve their educational aspirations according to the principles of Kaupapa Māori theory. As mentioned previously, Bevan-Brown (1998) argues for the importance of Kaupapa Māori theory as a foundation for Māori educational development because it stems from a Māori world view and is based on Māori epistemology and incorporates Māori concepts, knowledge, skills, experiences, attitudes, processes, practices, customs, reo, values and beliefs. The authors advocate that the SDEIMS will serve as a means of conveniently helping kura in systematically identifying and statistically evaluating their current situation in science curriculum delivery in Te Reo settings. Furthermore, it is hoped that the development of the SDEIMS will serve as a foundation for the development of other instruments unique to cultural settings in which the teaching of science from an indigenous perspective is in need of support.

As well, it is hoped it will be used in a manner similar to that in which the *Science Curriculum Implementation Questionnaire* has been used by hundreds of mainstream schools within New Zealand and internationally to monitor development as a result of in-service action (Lewthwaite, 2004). In the first author's experience, it is not uncommon for schools to initiate this process either as an internal response to perceived need of science delivery improvement or, more commonly, when they are regularly being externally evaluated by the Education Review Office or are reporting to their Board of Trustees. In supporting in-service action the data collected from staff completion of the SDEIMS are examined collectively by staff for accuracy. Generally, the data in the form presented in Table 1 suffice for supporting such discussion. In some schools the statistical means are represented graphically. Collective discussion then focuses on how to address the discrepancies between the Actual and Preferred scales. As Stewart and Prebble (1985) suggest, the use of data-collecting instruments as a foundation for school review is an accurate and time effective means by which an analysis of the school can be conducted. The data collected from these SDEIMS application exercises would confirm this assertion. For this reason, the use of evaluation tools such as the *Science Delivery Evaluation Instrument for Māori Settings* to provide a foundation for initial and ongoing school discussion, reflection and strategic educational, in particular, science curriculum improvement, is encouraged.

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APPENDIX

He Arotakenga Pūtaiao mō ngā Kura o Aotearoa

Kura: ____________________________
Kōeke/Tau _________________________

E 32 ngā pātai kei tēnei rārangi pātai. Ahakoa ka pai ake māhau anake ngā pātai e whakautu, ka taea (1) e koutou ko ētahi atu kaiwhakaako te mahi tahi (2) e ngā kaiwhakaako katoa rānei.

Hāngai katoa ana ngā pātai o te rārangi pātai nei ki te mahi whakaako Pūtaiao i tā te Māori e whakaaro ai. Ko tā te ***Pūtaiao*** he aki i ngā ākonga kia ako ai i te Pūtaiao o āianei me te hono hoki ki ngā tātai kōrero, ngā uara, ngā tikanga me te reo (Tāhuhu 1993). E whakatītina ai ngā ākonga kia whakawhanake ngātahi rātou i ō rātou māramatanga ki te mātauranga Māori me te mātauranga Pūtaiao o āianei. Ina akona tētahi, huri tuara ki tērā atu ka whāiti noa iho te tirotiro a te ākonga i te Pūtaiao ki te kura. Ina kē hoki me whātahi te mātauranga Pūtaiao o te ao tawhito ki tō tērā o te ao hou nei.

Hei whakautu pātai porohitatia te whakautu ki ōu nā whakaaro e whakaatu ana i te āhei o te kura ki te whakaako ngātahi i te Pūtaiao o Te Ao Māori me te pūatiao o āianei. Kia pono mai. Mā tō pono tō kura e āwhina kia kitea ai tētahi huarahi hei whakapai ake i ngā akoranga mō ngā ākonga.

Porohitatia te:		
	KW	ki te *kaha whakahē* koe i te kōrero.
	W	ki te *whakahē* koe i te kōrero.
	NT	ina *noho taiepa* ana koe.
	Āe	ki te *whakaae* koe ki te kōrero.
	TW	ki te *tino whakaae* koe ki te kōrero.

1.	Kei te whakaako au i te Pūtaiao ki tā te Māori e whakapono ai.	**KW**	**W**	**NT**	**Āe**	**TW**
2.	E tautokona ana taku mahi whakaako Pūtaiao ki tā te Māori e titiro ai.	**KW**	**W**	**NT**	**Āe**	**TW**
3.	E mātau pai ana au ki te Pūtaiao o āianei me tērā hoki o Te Ao Māori e hiahiatia kia akona e ngā ākonga.	**KW**	**W**	**NT**	**Āe**	**TW**
4.	E mārama pai ana au ki ngā ariā Pūtaiao e whakaakona ana ki ngā ākonga.	**KW**	**W**	**NT**	**Āe**	**TW**
5.	He nui te wā kei a au hei whakaako i te Pūtaiao ki tā te tirohanga Māori.	**KW**	**W**	**NT**	**Āe**	**TW**
6.	Kei te kaha tautoko mai te whānau o te kura kia ako ngā ākonga i te Pūtaiao ki tā te Māori e titiro ai.	**KW**	**W**	**NT**	**Āe**	**TW**
7.	Kei te kura tētahi mahere ako Pūtaiao e raupapatia nei ngā whenu kia whakaakona ai ki ia kōeke.	**KW**	**W**	**NT**	**Āe**	**TW**
8.	He pūkenga ōku hei whakaako i te Pūtaiao ki tā te Māori e titiro ai.	**KW**	**W**	**NT**	**Āe**	**TW**
9.	Kua rite pai au ki te whakaako i te Pūtaiao ki tā te Māori e titiro ai.	**KW**	**W**	**NT**	**Āe**	**TW**
10.	Kei te tautoko mai te kura i a au ki te whakaako i te Pūtaiaoe arotahi ana ki tā te Māori e titiro ai.	**KW**	**W**	**NT**	**Āe**	**TW**
11.	E mātau ana au ki ngā rautaki whakaako Pūtaiao e whātahi ana i tō āianei Pūtaiao ki tā te Māori.	**KW**	**W**	**NT**	**Āe**	**TW**
12.	E mōhio pai ana au ki ngā ariā Pūtaiao ka whakaako au i tā te ao Māori e whai ai.	**KW**	**W**	**NT**	**Āe**	**TW**
13.	Kāhore i te pērā te uaua kia whakarite wā hei whakaako Pūtaiao.	**KW**	**W**	**NT**	**Āe**	**TW**
14.	Kei te ārahi mai ngā kaiwhakahaere o te kura i te mahi whakaako i ngā marau pērā i te Pūtaiao ki tā te Māori e titiro ai.	**KW**	**W**	**NT**	**Āe**	**TW**
15.	Mōhio pū ana au ki ngā whenu o te marautanga Pūtaiao me whakaako e au.	**KW**	**W**	**NT**	**Āe**	**TW**
16.	E mōhio pai ana au ki ngā rautaki e pai ai te āwhina atu i ngā ākonga e ako ana i te Pūtaiao.	**KW**	**W**	**NT**	**Āe**	**TW**
17.	Ka tū pakari au hei whakaako i te Pūtaiao, ko ētahi o ngā whakaaro nō Te Ao Māori.	**KW**	**W**	**NT**	**Āe**	**TW**
18.	Kei te tautoko mai te taha whakahaere o te kura i te mahi whakaakoi te Pūtaiao ki tā te Māori e whai ai.	**KW**	**W**	**NT**	**Āe**	**TW**
19.	He pai taku mōhiotanga ki te ahurea Māori, tērā e hāngai ana ki te mahi whakaako Pūtaiao.	**KW**	**W**	**NT**	**Āe**	**TW**
20.	He pai taku mōhio ki ngā kōrero o te marautanga Pūtaiao ka whakaako mātou.	**KW**	**W**	**NT**	**Āe**	**TW**
21.	Ngākau nui ana au ki te whakaako Pūtaiao ki tā te Māori e titiro ai.	**KW**	**W**	**NT**	**Āe**	**TW**

22. Nō roto mai i te Kura he kupu ārahi hei āwhina i te mahi whakaako Pūtaiao ki tā te Māori e titiro ai. **KW W NT Āe TW**
23. He nui te mōhio o te Kura ki ngā tohutohu o te marautanga Pūtaiao, arā, he aha hei whakaako, āhea hoki whakaako ai. **KW W NT Āe TW**
24. He rauemi āku hei whakaako i te Pūtaiao ki tā te Māori e titiro ai. **KW W NT Āe TW**
25. Ki a au anō he pakari taku tū hei whakaako i te Pūtaiao. **KW W NT Āe TW**
26. Ka āwhina mai ōku hoa o te kura whānui i a au hei whakaako i te Pūtaiao ki tā te Māori e titiro ai. **KW W NT Āe TW**
27. Kua roa au e whakaako ana i te Pūtaiao ki tā te Māori e titiro ai. **KW W NT Āe TW**
28. Kua roa au e mahi ana i te ao Pūtaiao. **KW W NT Āe TW**
29. He wāhanga nui te mahi whakaako Pūtaiao o taku hōtaka whakaako. **KW W NT Āe TW**
30. Kei te hiahia aku ākonga ki te ako i te Pūtaiao ki tā te Māori e titiro ai. **KW W NT Āe TW**
31. Mā te hanga pai o te hōtaka Pūtaiao o te Kura ahau e tautoko i āku mahi whakaako whānui. **KW W NT Āe TW**
32. He kaitautoko kei tōku taha e whanake ai taku tū hei kaiwhakaako. **KW W NT Āe TW**

He mihi maioha tēnei mōu i whakautu mai i ngā pātai nei

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[i] At the time of writing both of the documents *Science in the New Zealand Curriculum* (Ministry of Education, 1993) and *Pūtaiao i Roto i Te Marautanga o Aotearoa* (Ministry of Education, 1996) were under modification.

[ii] The term Aboriginal in this paper refers to Indigenous cultures such as First Nation, Metis, Inuit and Māori, all populations in which the first author assists in science education research and development.