Questioning in Tongan science classrooms: A pilot study to identify current practice, barriers and facilitators

Jacquie L BAY[1]*, Fehi FOHOKO[2], Mumui LA'AKULU[3], Ofa LEOTA[2], Lesieli PULOTU[4], Sina TU'IPULOTO[3], Salesi TUTOE[4], Oliveti TOVO[4], 'Ana VEKOSO[4], 'Emeli H POUVALU[5]

[1]Liggins Institute, University of Auckland, Auckland, NEW ZEALAND
[2]Tonga High School, Nuku'alofa, Tongatapu, TONGA
[3]Tonga Side School, Nuku'alofa, Tongatapu, TONGA
[4]Kolisi Tonga 'Atele, Funga Manamo'ui, Ha'ateiho, Tongatapu, TONGA
[5]Independent education consultant, Tonga (Ministry of Education and Training, Tonga at the time of the study)
***Corresponding author on behalf of the Pacific Science for Health Literacy Project, Tonga Team.**

[1]Corresponding E-mail: j.bay@auckland.ac.nz

Received 21 Jun., 2016
Revised 26 Nov., 2016

Contents

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

Abstract

Questioning is central to the development of scientific and health literacies. In exploring this concept, Tongan science teachers hypothesized that their ability to use and encourage questioning presented challenges in the context of Tongan social and cultural norms. This study set out to develop a peer-to-peer protocol to enable teachers to characterize current practice, and identify barriers and facilitators to the use of questioning in Tongan science classrooms. Participating teachers co-constructed a peer-to-peer observation protocol, collected, anonymized and analyzed observational data to identify current use, enablers and facilitators of questioning in their classrooms. Findings suggest that peer observation and talanoa (collective critical discussion) enabled teachers to characterize and critique their current practice, and increased teacher understanding of the process of questioning and its value in the development of scientific and health literacy. Three hypotheses were developed to explore potential strategies to increase the use questions in Tongan science classrooms.

Keywords: Questioning, scientific literacy; talanoa; Tongan science classrooms

Introduction

The role of questioning in the development of scientific literacy

Scientific literacy (also referred to as science literacy) is identified internationally as a core objective within 21st century school science education (Douglas & Rodger, 2014; Millar, 2008). Definitions of scientific literacy are variable but all relate to the development of capabilities (knowledge, skills, attitudes, and values) that enable the use scientific knowledge

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

and understanding in decision-making at personal, community, and societal levels (Bybee, 1997; Laugksch, 2000; Millar & Osborne, 1998; OECD, 2013). The scientific literacy approach to science curricula arose initially from the need to address the purpose of science education in schools (Douglas & Rodger, 2014). Twentieth century science education was dominated by content-laden curricula. These were designed to train future scientists, and usually delivered using decontextualized didactic approaches (Osborne, 2007). Increasingly complex interactions between science and society in the latter half of the twentieth century demanded review of these approaches. Science education that supported the development of critical consumers of science as well as potential future scientists was required (Bull, Gilbert, Barwick, Hipkins & Barker, 2011; Osborne, 2007). Thus, the past 20 years has seen a gradual shift towards science education that promotes the development of knowledge, skills, attitudes, and values required to engage with and use scientific evidence. When embedded in a contextual approach this contributes to the cross-curricular task of development of critical, informed citizenship; a process enabling adolescents to engage with and act upon evidence relating to complex, open-ended, future-focused issues (Hipkins, Bolstad, Boyd, & McDowall, 2014). Such issues are associated with complex interactions between science, technology, health, the environment, economics, culture, and sociology. Thus, while the focus of this paper is on the role of questioning in the development of scientific literacy (including interactions between science and society), we note that in science classrooms exploration of such issues should be inextricably linked to the development of contributing capabilities such as health and environmental literacies (Grace & Bay, 2011; Zeyer & Dillon, 2014). Furthermore, exploration of multiple perspectives should evolve within the learning experiences. This enables students to explore and value diverse perspectives that include science (Kahn & Zeidler, 2016).

Development of scientific literacy requires critical thinking. This is associated with dispositions that encourage inquiry alongside questioning linked to observation, evidence-seeking, analysis, and examination of uncertainty, debate, and justification of decisions/positions/arguments. To cultivate critical thinking, learning environments should encourage students to ask questions, think about their thought processes, and develop habits of mind that enable them to transfer critical thinking skills from the classroom to life situations (Molnar, Boninger, & Fogarty, 2011). Therefore, questioning is an essential component of learning environments that promote development of scientific literacy and contribute towards life-long critical informed citizenship.

Questioning in Tongan Science Classrooms

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

The Pacific Science for Health Literacy Project (PSHLP) is a multi-sectoral partnership involving education, health, and science communities in Tonga, the Cook Islands, and New Zealand (NZ). The project supports the development of capabilities required for adolescents to explore and take actions relating to the non-communicable disease (NCD) epidemic, a complex, open-ended issue of significance in Pacific Island communities (Bay & MacIntyre, 2013). Health literacy is identified as a core capability alongside scientific literacy required to enable students to negotiate health-related SSIs (Bay, Morton, & Vickers, 2016). Health literacy is associated with application of knowledge, skills and self-efficacy enabling evidence-based decision-making and actions related to health and wellbeing (Nutbeam, 2000). As with scientific literacy, this is applied at the level of personal, community, or societal decision-making and is considered critical to empowerment (Nutbeam, 2000; 2008). Therefore in the context of the PSHLP project and this study strategies to support the development of health literacy and scientific literacy are examined simultaneously within PLD.

Practicing teacher capability development is a key component of PSHLP. This supports teachers to make evidence-based decisions related to learning and teaching that facilitate improved development and application of scientific and health literacies within the adolescent population. Learning resources contextualized in aspects of the NCD epidemic have been co-constructed by the project team. Narratives supporting students to explore research evidence are central to the pedagogy on which these resources are based (Bay, Vickers, Sloboda, & Mora, 2012; Grace & Bay, 2011). Through these stories, students explore factors contributing to the NCD epidemic, develop relevant knowledge and understanding (conceptual, process and epistemic), examine scientific and health data (reimaged to suit the age of the students), and construct evidence-based arguments for actions that they could undertake to support NCD risk reduction in their families and school communities.

During professional learning and development (PLD) workshops examining interactions between and the development of scientific and health literacies, teachers within the PSHLP Tonga team identified a dilemma with regard to the importance of questioning as a capability required for the development and application of scientific literacy. The teachers proposed that questioning, debate and argumentation were not actively encouraged in classrooms within the team, nor in many Tongan families. While the teachers agreed that the development of critical thinking was a stated aim promoted in schools participating in the project, they felt that in practice, a combination of traditional teacher-centered classrooms and cultural factors meant that minimal questioning occurred. The teachers proposed that it was very difficult to support students to use scientific and health evidence in decision making if students had little

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

experience of questioning and argumentation at school or at home. This hypothesis sits well with established literature examining the importance of argumentation in science, and thus in science education (Chin & Osborne, 2010; Lawson, 2003).

This dilemma is not unique to Tonga. Addressing respectful silence in learning within Pacific cultures is well documented (Chu, Abella, & Paurini, 2013; Lee Hang & Bell, 2015). In Tongan culture, faka'apa'apa (to be respectful, humble and considerate) is an important quality (Vaioleti, 2006). Traditionally, questioning and asking questions is not seen as a process supportive of development of knowledge, clarification, or understanding. Rather it is seen as questioning the authority of the elders, being parents, teachers and all those that are supposed to 'know' and are expected to tell others what to do, or give instructions. While indigenous knowledge and culture is often incorrectly perceived by western-dominated thinking as being timeless, this is not the case (Quanchi, 2004). In Tonga there is a gradual drift from the traditional position on questioning to one that finds questioning acceptable, depending on who is asking the question and for what purpose the answer is going to be used. This is particularly evident in younger generations with acceptance from some that the one who is questioned is expected to 'know' (therefore is being respected) and is ready to share information for learning. Therefore if the question is not challenging the authority of traditional thinking, but is asking for clarification or elaboration, and the respondent is prepared to engage, questioning may occur.

The PSHLP teachers proposed testing of two hypotheses to establish understanding of their current practice with regard to questioning in science classrooms and enable a baseline from which action research could be developed and evaluated

1. That issues associated with questioning and respect in Tongan culture limit opportunities for questioning and discussion in classrooms, impacting potential for students to develop critical thinking capabilities required for development and application of scientific and health literacies.
2. That while open questions were supportive of development of capabilities associated with critical thinking and scientific inquiry, where questions were used by teachers in science classrooms in Tonga, these tended to be closed questions.

The testing of these hypotheses via participatory action research placed the PSHLP teachers in the role of teacher-researchers (TRs) within this study. They identified this as an important aspect of their professional development within the PSHLP intervention, growing their capacity to support the development of scientific and health literacy in adolescents via learning contextualized in exploration of the NCD epidemic.

Purposes

To develop a peer-to-peer protocol enabling teacher-researchers to characterize current teacher-led questioning practice and identify barriers and facilitators to the use of questioning in Tongan science classrooms. By utilizing an action-research approach, the study encourages teachers to engage in an ongoing 'Teaching as Inquiry' cycle (Ministry of Education, 2007; Weinbaum, Allen, Blythe, Simon, Seidel & Rubin, 2004).

Methods

Study Design: Talanoa-based participatory action research

Within PSHLP-Tonga, methodologies grounded in Tongan thought and culture are purposefully used to ensure that study methods are centered within a Tongan epistemology. The study used a talanoa-based qualitative participatory action research (PAR) methodology. Talanoa is a communication medium shared amongst Pacific cultures. It is a process of conversation, storytelling, relating of experiences, aspirations and views and listening to different voices within respectful relationships (Halapua, 2008; Vaioleti, 2006). Talanoa allows authentic ideas to be expressed which may lead to "critical discussions or knowledge creation that allows rich contextual and inter-related information to surface as co-constructed stories" (Vaioleti, 2006).

The PSHLP professional development workshops within which the dilemma relating to questioning in Tongan science classrooms arose were also based on concepts of talanoa, emphasizing the importance of voices being heard, and most importantly listening purposefully. The depth to which listening occurs is central to talanoa, and from this emerges communication and dialogue where respect and attention is given to all participant voices (Halapua, 2008). Through talanoa, a safe space is created for dynamic processes supporting critique, from which can emerge evidence-based actions that are appropriate for the social and cultural context. In the case of our talanoa pertaining to scientific and health literacy development, through a process of sharing and listening, reflections emerged that developed into a question, from which the action research reported in this paper has arisen.

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

A summary of the action-research process is presented in Figure 1. Details of the setting and each component of the methods are described in the paragraphs that follow. The PSHLP study was approved by the University of Auckland Human Ethics Committee (Ref. 011207), the Tonga National Health Ethics Research Committee (Ref. 040614.2). The study was approved by the Director of Education, Tonga Ministry of Education and Training.

Defining the Research Question	The research question emerged within PSHLP teacher PLD examining scientific and health literacies, and their relevance to science education in Tonga. Consensus was sought from the Ministry of Education and Training (MET), participating schools and teachers to investigate the use of questions by teachers within the PSHLP-Tonga study group via teacher observation, an approved research method in the PSHLP project.
Co-construction of the study protocol	**Workshop A (3 hours):** The Study Design Workshop explored concepts associated with types of questions, use of questions in classrooms, and research methods. A protocol based on the approved teacher-observation protocol was co-constructed. This involved formation of trusted-peer partnerships within the teacher-researcher team; invited observation of a teaching episode; data analysis and interpretation via collaborative workshop. The protocol was confirmed by MET & participating schools.
Data Collection	**Classroom observations with a trusted peer.** Teacher-researchers (TRs) self-selected into pairs. Within pairs, one member elected to teach and the other to observe. TR pairs agreed on a time and context for the observation focusing on the use of questions by the teacher in a 10-20 minute episode within a science lesson. The observer recorded questions asked by the teacher and the number of student responses. Both TRs conducted written self-reflections and shared these with each other at a mutually agreeable time. Agreed data was submitted to project lead (PL).
Data Analysis	**Workshop B: 4 hours;** Facilitated by the PL the workshop introduced TRs to concepts of qualitative data analysis. A consensus coding criteria evolved from sharing of results of small group coding of anonymized data. This process was supported by the development of coding exemplars via discussion & consensus. The group coding process was repeated until consensus was achieved. Six TRs were elected by the group to summarize the findings. **Workshop C: 4 hours;** Facilitated by the PL; 6 elected TRs working in pairs summarized and presented the data analyzed in Workshop B in written formats in preparation for internal peer review.
Writing & Peer Review	**Workshop D: 2 hours;** Facilitated by the PL and attended by all TRs. The 6TR group presented the findings of Workshops B and C. Peer review discussions involving all TRs were undertaken. These resulted in agreed instructions for the

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

	6TR group to complete development of a research poster and seminar presentation. **Workshop E: 1 ½ hours;** Facilitated by the project leader and attended by the 16 TRs. The 6TR group presented the draft poster and seminar. Peer review occurred via small group and then full-group discussion. The 6TR group undertook to make collectively agreed changes.
Communication	**Seminar presentation:** The 6TR group presented the seminar on behalf of the team. The audience consisted of the CEO of Education, principals and teachers from participating schools. The 30 minute seminar presentation was followed by a response from the CEO and an open discussion. TRs were presented with a certificate of achievement by the CEO of education. A shared meal for the TRs, their families and school/MET leadership provided a culturally appropriate celebration of the achievements of the TR team. Final adjustments were made to the poster presentation via consensus following comments from CEO and Principals. A0 and A3 copies of the poster were distributed to participating schools for use in school-staff discussions. TRs from each participating school gave seminar-presentations to full staff meetings. These were supported by the PL and the school principal. Departmental discussion and planning for actions based on the evidence presented in the seminar followed.
Year-end reflections	Annual PSHLP teacher focus groups were used to gather evidence regarding ongoing impact of the action research program.

Figure 1. Study flow diagram

Setting and Participants

Tonga is a middle-income Pacific Island nation, with a population of just over 100,000, 56% of whom are less than 15 years of age. Approximately 73% of the population reside on the main island of Tongatapu (Tonga Department of Statistics, 2011). The study team consisted of 16 practicing science teachers and one deputy principal from three government schools on the island of Tongatapu, and the project leader. Two of the schools conduct lessons in English, supplemented by Tongan, and one uses Tongan exclusively. Teacher-researchers were strongly supported by the principals of each school. The teacher-researchers all teach science in Forms 1–2/Years 7–8, where students are 11 to 13 years-old. Most also teach science through to Form 5/Year 11. Other than one, the deputy principal and principals supporting the team were not science teachers. Their role was in linking the project to learning and teaching practice PLD in participating schools, ensuring the teachers felt confident that they could try new ideas within the project. The majority of teacher-researchers have a diploma in teaching but have not had the opportunity to undertake university level study in science. This is typical

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

of form 1–5 science teachers in Tonga where only 3% of the population have a tertiary qualification (Tonga Department of Statistics, 2011). The research was the first experience of action research for the teacher-researchers, but not the principals. Teacher-researchers recorded their written intentions, observations and reflections in English. Discussions occurred in both Tongan and English throughout the research process. The project was overseen by the CEO of Education. This leadership gave permission for teachers and schools to openly explore their practice.

Data Collection

Peer-to-Peer (teacher-to-teacher) observation was used to gather data on typical teaching practice with eight of the sixteen teacher-researchers in the project group participating in data gathering as teachers and eight as observers. This process is described in Figure 1. All teacher-researchers were familiar with classroom observation by a principal or deputy principal for appraisal, but peer-to-peer observation was novel. Participating teachers identified a science lesson with a Form 1 or 2 class in which they intended to undertake active questioning with the class-group. Learning intentions were exchanged with a trusted peer who was invited to observe the questioning episode within the lesson and record observations using a standardized observation record sheet. The observer categorized questions used by the teacher as open or closed, recorded the number of students offering to respond to each question, and the number of student questions arising from each teacher question. Student responses and questions were not recorded. Following the teaching episode reflections were recorded by both the teacher and observer independently, prior to meeting to exchange and discuss reflections. Following this meeting final reflections were recorded and development goals set.

Data Analysis

A series of workshops described in Figure 1 were used to introduce participating teachers to qualitative data analysis methods including coding and inter-researcher consistency, a process that was novel to all participating teacher-researchers. Coding was undertaken in small groups to support research capability development in the teacher-researchers. An inter-researcher coding consensus development process during Workshop B was used to establish codes. Groups of four teachers were given anonymized data from two TR pairs and required to code each teacher question as open or closed. Groups were then required to share and justify their coding, initially with one other group, and then with the entire workshop. This process revealed variation within and between groups arising from inconstant conceptions of open and

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

closed questions. Through the talanoa process of open and respectful dialogue, the groups were able to collectively agree on perceptions of open and closed questions, and reach consensus on the coding system. During this process, questions were placed along three continuums, initially in a linear manner, and then within a three-dimensional axis (Figure 2). Open and closed questions were distinguished by the potential for multiple acceptable answers (open) vs defined answers (closed) and cognitive demand (represented by simple to complex in the axis), being greater for open questions (Kawalkar & Vijapurkar, 2013). Within the cognitive demand axis the terms 'recall', 'explain' and 'analyze' were used to categorize questions. The passive to active axis represents the group's interest in student-centered learning environments, a significant focus of PLD with the project, and a strategic focus within the Lakalaka Policy Framework being implemented in schools at the time of the project (Ministry of Education and Training, 2012). This was not used in the coding process as all questions in the collected data were passive. However, we have included this as it represents the questioning framework that the teacher-researchers aspired to and can be used in future action-research. In developing this coding frame exemplars were established from the data as well as from recent teaching experiences (Figure 3). Notably, once a collection of exemplars was established by the research team, categorization occurred more rapidly.

Coding of reflections was conducted via a constant comparative approach with inductive reasoning (Boyatzis, 1998). A talanoa-based group discussion was used to establish inter-researcher consistency in the manner described above.

All statistical data analyses were performed using SPSS version 23.0 (IBM Corp, 2015). Talanoa followed by peer review were used to support the process of data analysis, writing and seminar presentation development. Themes emerging from the analysis were used to form three hypotheses for future investigation.

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

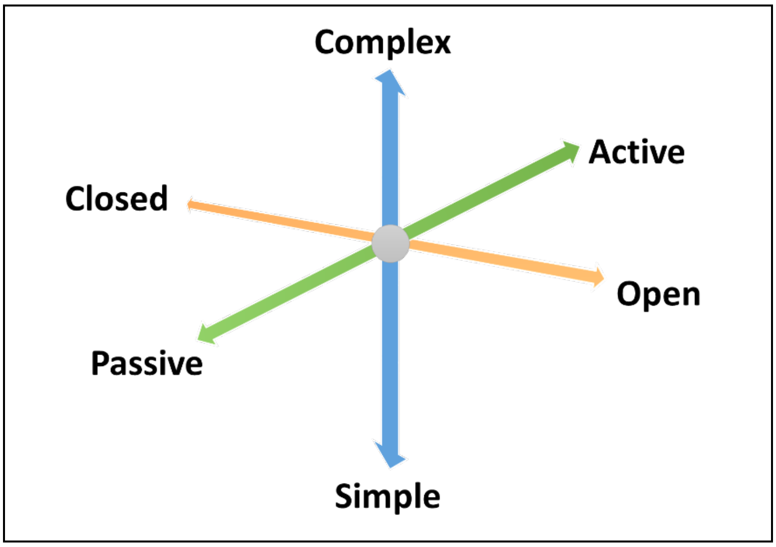

Figure 2. Interacting components of teacher-initiated questions identified by teacher-researchers to support coding of questions represented in the data.

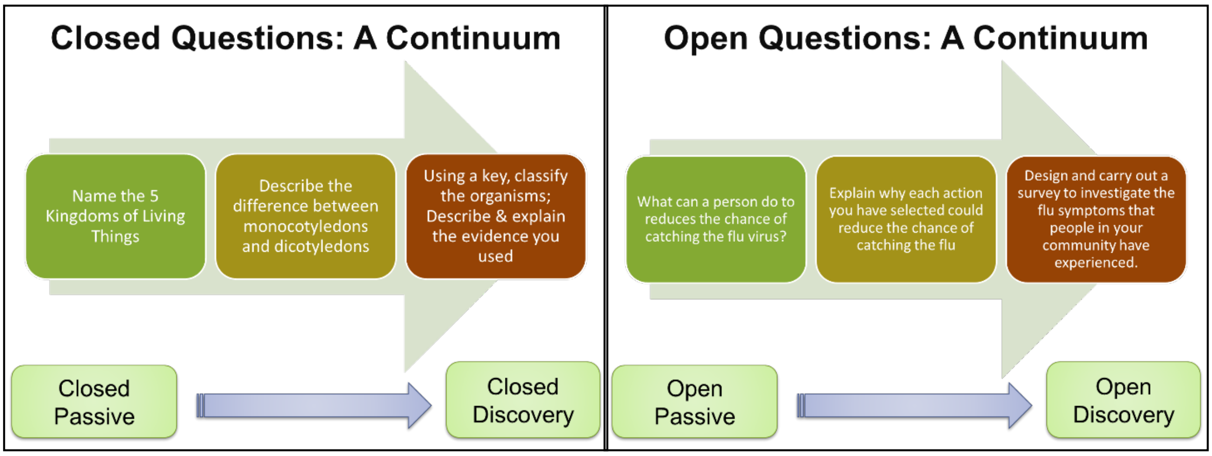

Figure 3. Exemplification of open and closed questions on a continuum: used to support teachers in the process of coding of question characterization data.

Findings and Discussion

Characterization of questions used by teachers in Form 1 and 2 science classes

Seven of the eight participating teacher-observer pairs collected quantitative and qualitative data from the observation exercise (Table I). At the point of personal reflection (prior to Workshop B), teacher-researchers categorized the majority of the questions they or their observation partner asked as open (77%). Analysis of these data following the coding consensus development process in Workshop B resulted in only 15% of questions being coded as open. The final collective classification is presented in Table I. This indicates that closed questions (85%) were more likely to be used in the teaching episodes ($\chi^2(1) = 24.923$, $p<.001$).

Table II. Examples of typical questions used by teachers in these learning episodes

Closed Questions	Open Questions
What do you call the process that plants use to make their food? *Where does photosynthesis take place?* *What were the three types of microbes we studied in our last class?*	*What should the community or government do to assist in preventing this disease?* *Explain how roots help plants.* *In what ways could you help to avoid the spread of viral infections?*

Table II provides examples of closed and open questions observed in the learning episodes. Closed questions were typically used to examine students' content knowledge, potentially reviewing prior learning. Teachers reflected that these were intended to be easily answered by students to encourage participation.

> *"In my introductory activities I start using questioning to check students' prior knowledge….most of my questions are easily answered correctly by the students."—Teacher 7*

> *"I opened with the easiest questions I could ask…and three students answered correctly all at once. I asked the others [students] to give them a big hand before praising them myself…Students who frequently give positive responses and frequently receive positive reinforcement tend to attempt almost every question, without being asked, with great enthusiasm" —Teacher 8*

In contrast, open question used by the teachers targeted exploration of more complex concepts or issues, and provided opportunities for students to engage in explanation and analysis.

The level of cognitive demand in teacher questions was characterized using recall, explanation, and analysis, representing increasing cognitive demand from recall to analysis. Closed questions were more likely to require recall (80%) than explanation (20%) ($\chi^2(1)= 15.356$, $p<.001$) (Analytical questions were not considered in this analysis). Analysis of the

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

open questions is limited by the small sample size (n=8). However, the trend in the data is towards increased frequency of questions requiring explanation (5) and analysis (2), compared to recall (1).

Observing teachers counted the number of students offering to respond to each question and the number of student questions that arose from a teacher-led question. On average, students were more likely to offer to respond to closed questions ($\chi^2(1) = 9.000$, $p=.003$). However, the type of teacher-led question (open or closed) had no impact on the likelihood of student-generated questions arising ($\chi^2(1) = 0.818$, $p=.366$).

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

Table I. Categorization of teacher questions and student responses

Participating Teacher	Observation time (min)	Number of teacher questions	Final categorization of questions asked by teachers																				Student responses to teacher questions*				Student questions arising from teacher questions			
			Closed Questions Number *(% Total)*		Categorization of closed questions						Open Questions Number *(% Total)*		Categorization of open questions						Closed		Open		Closed		Open	
					Recall		Explain		Analyze				Recall		Explain		Analyze									
					Number *(%)*								Number *(%)*						Number *(Average)*				Number *(Average)*			
1	20	11	11	*(100)*	8	*(72.7)*	3	*(27.3)*	0	*(0.0)*	0	*(0.0)*	n/a		n/a		n/a		35	*(3.2)*	n/a		10	*(0.9)*	n/a	10
2	10	3	2	*(66.7)*	1	*(50.0)*	1	*(50.0)*	0	*(0.0)*	1	*(33.3)*	0	*(0.0)*	0	*(0.0)*	1	*(100)*	26	*(13.0)*	18	*(18.0)*	5	*(2.5)*	3	*(3.0)*
3	10	4	3	*(75.0)*	2	*(66.7)*	1	*(33.3)*	0	*(0.0)*	1	*(25.0)*	0	*(0.0)*	0	*(0.0)*	1	*(100)*	17	*(5.7)*	9	*(9.0)*	0	*(0.0)*	0	*(0.0)*
4	15	9	8	*(88.9)*	8	*(100)*	0	*(0.0)*	0	*(0.0)*	1	*(11.1)*	0	*(0.0)*	1	*(100)*	0	*(0.0)*	57	*(7.1)*	0	*(0.0)*	0	*(0.0)*	0	*(0.0)*
5	10	4#																								
6	15	11	11	*(100)*	9	*(81.8)*	2	*(18.2)*	0	*(0.0)*	0	*(0.0)*	n/a		n/a		n/a		52	*(4.7)*	n/a		0	*(0.0)*	n/a	
7	11	5	4	*(80.0)*	2	*(50.0)*	2	*(50.0)*	0	*(0.0)*	1	*(20.0)*	0	*(0.0)*	1	*(100)*	0	*(0.0)*	32	*(8.0)*	6	*(6.0)*	0	*(0.0)*	0	*(0.0)*
8	20	9	5	*(55.6)*	5	*(100)*	0	*(0.0)*	0	*(0.0)*	4	*(44.4)*	1	*(25.0)*	3	*(75.0)*	0	*(0.0)*	98	*(19.6)*	4	*(1.0)*	16	*(3.2)*	3	*(0.8)*
Total		**52#**	**44**	***(84.6)***	**35**	***(79.5)***	**9**	***(20.5)***	**0**	***(0.0)***	**8**	***(15.4)***	**1**	***(12.5)***	**5**	***(62.5)***	**2**	***(25.0)***	**317**	***(7.2)***	**37**	***(4.6)***	**31**	***(0.7)***	**6**	***(0.8)***

#Teacher 5 asked four questions in the teaching episode, three of which the observer categorized as open. The observer did not record the questions. Therefore, analysis was not possible and these questions were not counted in the total.
* During analysis it was confirmed that observers recorded the total number of students offering to respond/question (indicated by hand-up). Reflection within the group recommended for future use of the protocol that both the number of students indicating willingness to respond, and the number of students that teachers allowed to respond should be recorded.
Expecting students to respond to questions en masse was common practice for participating teachers. This explains data such as 98 students responding to 5 questions (Teacher 8)

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

Barriers and Facilitators

In examining the data two key themes emerged, that of barriers and facilitators. Following the collective coding process, each group went back to the data and examined the reflections to identify common barriers and facilitators. The frequency with which these occurred in self or peer reflections was recorded in Tables III and IV.

That there is a need to increase student interaction and reduce the presence of silence in classrooms was not denied by the teacher-researcher team.

"I really need my students to break the silence." —Teacher 7

As hypothesised, the peer observation evidence suggests that factors associated with socio-cultural context contribute to barriers that potentially reduce the use of questioning. These include respect for teachers as elders, who because of their position should be respected and potentially may be seen by some students as people who should not be questioned (Table III).

The highly structured environment typical of classrooms in the participating schools, as well as a strong desire by all (teachers and students) not to be incorrect, are identified as barriers that can be addressed, and link back to the wider socio-cultural context of the school communities..

"Maybe that [students answering questions all at the same time] is the reason why my students are usually quiet. They always wait for my orders to throw it to them to answer it together at the same time." —Teacher 7

"Most of the students respond by sitting up straight….some look at their books before looking at the teacher." —Observer of Teacher 3

"[You were] very effective. Students were very attentive. A very loud and demanding voice captured students' attention." —Observer of Teacher 6

"Another barrier… was the frequent wrong answers given by some students. Actually I wanted to ask them more questions but because I knew they will be discouraged if they continue to give wrong answers, I was reluctant to ask those students more." —Teacher 8

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

Table III: Barriers to the use of questions by teachers, identified from self-reflection and peer observation.

BARRIERS	Examples from the Peer-to-Peer Questioning Reflections	Frequency
Students worried about giving wrong answer.	*"In our Tongan classrooms, some of the students do not respond to the questions because once their answers are not correct some of their peers might laugh or mock them."* —Teacher 1	4
Time Limitations	*"I had found out from my colleague that I did not allow some of the students to respond to my questions but they were willing to answer the questions."*—Teacher 1 *"I did not give adequate thinking time for students about certain questions."*—Teacher 8	3
Personal past experience of students	*"I almost asked one of the students to explain the harmful effect of virus on our bodies, but then I remembered that the child [had] lost a loved one because of AIDS, I refrained myself from asking the question to that particular student."* —Teacher 8	1
Lack of visual resources to support students to understand the question	*"I should have got pictures of real animals to help my questioning"*—Teacher 5 *"I should have shown students the process of osmosis by bringing tapioca and a container of water and do the activity."* —Teacher 6	5
The impact of cultural norms	*"Culture is another barrier. In our school some of the students really respect the teachers and avoid - the students do not come close to the teacher and build a barrier between the teacher and the student. When we ask the questions the students are afraid to respond to the questions, and this makes the students keep silence all of the time."* —Teacher 1 *"Students cannot openly discuss this as it is a taboo subject according to tradition and customs … and there*	4

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

	are cousins and close relatives in the same class."—Teacher 2	
Literacy Barriers	*"Difficult scientific terms that may be too complicated for students and hard to express."*—Teacher 2 *"Last but not least - my English and language skills."*—Teacher 7	3

Table IV: Facilitators to the use of questions by teachers, identified from self-reflection and peer observation.

FACILITATORS	Examples from the Peer-to-Peer Questioning Reflections	Frequency
Using questions to encourage participation.	*"Students who are involved and participate in discussion and questions [build] self-confidence to bring out their views and ideas."* —Teacher 1 *"... formulate questions based on their wrong responses [to] guide questioning [towards] the correct answer."* —Teacher 8	7
Knowing your students: recognising and addressing needs.	*"…but then I remembered that the child has lost a loved one to AIDS. So I refrained from asking the question to that particular student. Instead of asking that particular question [in class] I used it as a homework question… to be [completed] in pairs. I assigned one student in each pair to [answer] the question, and the other students to do the task..."* —Teacher 8	2
Positive reinforcement	*"Instead of myself reinforcing their positive responses directly I asked others to give them a big hand before I praised them myself"* —Teacher 8	6
Using differentiation to meet the variable needs of students	*"I rephrase the wording of the questions to make it clearer to students..."*—Teacher 1 *"…attention should be given to the wording of the questions to ensure coherency between levels of difficulties of the words used…"*—Observer of Teacher 8 *"The questions uses needed to be worded with simpler phrases or words ..."*—Teacher 8	6
Using visual, hands-on or experiential resources to encourage engagement	*"…[you could] provide a health talk from an organization…"* —Observer of Teacher 2 *"A fieldtrip would be helpful...."* —Teacher 3 *"I should have got pictures of real animals to help with my questioning."* —Teacher 5	4

The impact of teachers as researchers

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

The study placed teachers in the role of researchers, supporting empowerment of teachers to become adaptive experts, who are "engaged in ongoing cycles of inquiry and knowledge building to develop their expertise in response to specific challenges students face." (Timperley H., 2011). Because of this resultant empowerment, the process through which these outcomes were established is potentially more important than the baseline characterization itself. McIntyre defines four principles that are core to PAR methodologies, each of which we identified in the process that led to the development and undertaking of this study. These are "(a) a collective commitment to investigate an issue or problem, (b) a desire to engage in self- and collective reflection to gain clarity about the issue under investigation, (c) a joint decision to engage in individual and/or collective action that leads to a useful solution that benefits the people involved, and (d) the building of alliances between researchers and participants in the planning, implementation, and dissemination of the research process" (McIntyre, 2008,p.1). These principles fit well with a talanoa methodology. The PAR process has established a model that can be applied by this research group in ongoing analysis and development relating to the issue of questioning, or to other challenges they identify.

Analysis of the process also indicates that it represents the work of a professional learning community (PLC) promoting teaching as inquiry, and the role of teachers as researchers engaged in analysing and addressing issues critical to supporting student learning. Core to this classification is the notion that in contrast to one-off workshops known to be ineffective in facilitating change, the PLD workshops in the model were part of a series that provided a foundation for ongoing critical reflection and analysis, supported by internal and external leadership over an extended period (Lumpe, 2007). This is reflected in a focus group discussion held with teacher-researchers at the end of the academic year in which the work was initiated.

> *"It was different [to prior PLD] because you [external project leaders] kept coming back to us - we kept coming back together – that made us do something, we could not just go - I'm too busy..."* —Participating teacher-researcher, School A; focus group

> *"We talked together – it was not just being talked at."* —Participating teacher-researcher, School B; focus group

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

> *"Also the [PLD] program had real examples – we were hands on learners, so that works for us as well as the kids!"* —Participating teacher-researcher, School C; focus group

PLCs are characterised by shared values and vision, collective responsibility, reflective inquiry, collaboration, and group as well as individual learning (Stoll, Bolam, McMahon, Wallace, & Thomas, 2006). These characteristics can be identified in the focus groups comments as well as within the process and outcomes of the study. Shared values and vision, while established earlier in the project at a high level (Bay & MacIntyre, 2013), were co-constructed by the PLC within Workshop B. This involved defining the research process that was required in order to address the question of interest, which sat within the overarching shared project goals relating to scientific and health literacy development.

The PAR process enabled the team to critically examine and reflect on their practice, and the frames of reference supporting that practice with regard to the use of questions in learning and teaching. The emerging evidence supported the hypothesis that questioning, when used, was more likely to be closed. The significant shift from initial to final coding with regard to what constituted open or closed questions demonstrates that participants engaged in a transformative learning process. Key elements of transformative learning seen within the process include identification of prior experience and critical reflection within a community of learners (Taylor, 2011). This supported the questioning of assumptions, promoted awareness of the presence of alternative perceptions and led to changed perceptions that were in turn examined in greater depth.

While exploring concepts associated with the use of questioning in learning the team were aware that they in turn would be facilitating the process of examination of the role of questioning in science learning with other teachers. They reflected that identification of exemplars had been useful to them in refining their perceptions of categorisation of questions (Figure 3), and hypothesised that such exemplars could support other teachers to analyse the types of questions being used in classrooms. In order to develop the continuum exemplars represented in Figure 3, the team had to imagine learner centred activities that represented the far right of the continuum as they identified that such questions were not as a common part of their current practice. The associated PLD programme had introduced learner-centred discovery activities, so these were not unfamiliar in theory. The PLD had enabled teachers to experiment as a group with these, but the team was yet to apply these ideas in practice. That learner centred activities could be imagined for learning contexts and topics beyond the

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

project represents the potential offered by talanoa to facilitate active engagement and learning in this professional community.

> *"There were actual learning resources that we could trial to use these ideas - in the past we just get told - do this, do that - there are never any examples of how we could change things in our classrooms."* —Participating teacher-researcher, School A; focus group

The evidence suggests that the process of participating in action research created opportunities for participating teacher-researchers to question assumptions with respect to the use of questions in science learning, test out the use of questioning, and reflect on how students responded to this different approach to learning and teaching.

> *"During my questioning session, I can feel how the learning environment changed in this time. Once I start asking questions, some of my students [were] eager to respond to the questions and some do not. For the students who involve and participate in the discussions of the questions, they build self-confidence which brings out their ideas and view about the questions. At this time, some of the students [are] against the opinion and view of some other students and even my ideas but this builds up some new questions for me to ask the students. At this stage, it shows me that some of my students can critically analyse some of the answers to the questions.* —Teacher 1

Furthermore for some teachers it provided an important opportunity for identification of potential changes in their practice that could enhance the ability of students to engage in open-ended dialogue, through which learning could occur.

> *"From my colleague's reflections, the wording of some of my questions were a bit advanced for my students and needs improvement. The students failures in their first attempts to answer some of the questions correctly was not due to unknowing, but rather misunderstanding of the questions. Another weakness……was that I did not give adequate thinking time for students…..mostly with questions that required an explanation. ."* —Teacher 8

These reflections indicate that teachers are testing, or proposing to test perspectives or activities different to those typical of their practice. This is a hallmark of transformative learning.

Overall, the reflections indicate teacher-researcher awareness of cognitive and social needs of students within the classroom and a strong desire to support student learning. The PAR

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

process utilising collective critique and analysis offered the opportunity for teachers to identify potential actions that could be tested to understand how to enhance learning. This resulted in the development of an action research question relating to strategies that may enhance the use of questions in Form 1 – 5 Science classrooms in Tongan schools. Specifically from the evidence it was identified that the following three hypotheses should be investigated:

- That engaging in hands-on learning activities will support increased student participation in questioning.
- That engaging in learning experiences supported by visual stimuli will increase student participation in questioning.
- That placing questions within a Tongan cultural framework will increase active and effective student participation in learning.

These hypotheses offer teacher-researchers potential actions that could be evaluated using the methods established in this pilot study.

Limitations

The potential for participation in research to impact the behaviors of the participants should be acknowledged as a limitation of this study. This is highlighted by the lesson intentions and reflections from participants, examples of which are indicated below.

> *"Questioning is a key part of the teaching-learning process in any classrooms of any level. All strategies used to impart a teaching concept in the classrooms to the students will surely fail to bring out the desirable learning outcome if questioning is not or less used while the lesson is undertaken.* ***Thus I will ask more number of questions in this period than I have ever used before in my science classes"*** —Lesson intentions, Teacher 8

> *"The purpose of this lesson is for all learners to identify and label these two plant systems - shoot system & root system and also to describe the function of each part of the two systems.* ***I was planning to spend most of my questions in open questions because I really need my students to break the silence and come out from their shells. They are all capable but they need to be more curious".*** —Lesson intentions, Teacher 7

> *"From this teaching episode,* ***I have found out how the use of open-ended questions in teaching is really effective.*** *Not only [does] it engage students to participate and express*

> *their ideas and opinion about the questions but it also make other students criticized the ideas of others."* —Lesson analysis, Teacher 1

These records indicate that the learning episodes selected for observation by these teachers may not have been typical of their practice. The statements indicate towards usual learning environments where interaction via questioning may be more limited than that observed in this action research setting. This reflects research participation effect, an extensively documented phenomena in human behaviour research, but one that is not fully understood in terms of research design to minimise impact (McCambridge, Kypri, & Elbourne, 2014).

The number of observations could also be considered as a limitation. However, this is a pilot study limited to three schools collaborating in the project and defined by the teacher-researcher team as the extent to which they could enable data collection. Potentially a larger research team or observations outside of the team could have exposed further factors, however the limitation of observation and analysis to the active research team was an intentional act within the design, identified as being important as trust was established within and between the teachers in this group and the group leaders.

This study only examined the content of questions asked by teachers. Once teachers are confident in the use of this method it should be extended to include analysis of the content of student responses and student questions.

Conclusion

This study evolved from identification of a dilemma within the project team with respect of the absence of questioning and argumentation within many Tongan science classrooms. The objective of developing a methodology to identify evidence of the extent of this issue from which it could be examined and potentially addressed has been enabled by the study. The use of peer-to-peer observation and reflection with anonymized data being analysed within a respectful group setting enabled an environment in which teacher-researchers could confidently participate in analysis and critique of classroom practices. This identified that where questions were being used they were likely to be closed, thus limiting opportunities for discussion and argumentation. It supported the development of pedagogical content knowledge pertaining to questioning as a tool for the development of engaged learning.

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

Key factors identified as barriers to the use of questions in Tongan science classrooms were linked to the socio-cultural factors that teachers hypothesised to be barriers to the use of questions in learning.

Factors relating to supporting and scaffolding students were identified by participating teachers as positive facilitators that were or could be put in place to increase the confidence and ability of students to ask and answer questions, thereby developing understanding and capabilities.

The PLD process imposed expectations of action on participating teachers. This included taking responsibility for analysis of research findings, communicating these formally within the project collective and their school, and making resultant evidence-based decisions about practice. This is a highly action-oriented PLD process, which we propose led to increased pedagogical content knowledge and its implementation in practice. We will report on the next stage of this work in due course, identifying how the teacher-researchers implemented actions in their practice, and their roles as leaders within their professional communities.

Acknowledgements

The authors wish to thank all members of the PSHLP Tonga team for their contributions to this study. The authors thank Mrs Soana Pamaka for her ongoing mentorship and constructive reflections; Mrs 'Amelia Folaumahina, Mr Tevita Kalafatoni Latu and Mrs Asena Ma for their support of the project vision and the teacher-research teams in each school. The work represented is supported by a grant from NZAid.

References

Bay, J., Morton, S., & Vickers, M. (2016). Realizing the Potential of Adolescence to Prevent Transgenerational Conditioning of Noncommunicable Disease Risk: Multi-Sectoral Design Frameworks. *Healthcare, 4(3)*, 39.

Bay, J. L., & MacIntyre, B. (2013). *Pacific Science for Health Literacy pre-feasibility study report*. Report prepared for the New Zealand Ministry of Foreign Affairs and Trade. Auckland: University of Auckland. Retrieved from http://www.lenscience.auckland.ac.nz/en/about/partnership-programmes/pacific-science-for-health-literacy-project/Feasibility.html 24 Febrauray, 2015.

Bay, J. L., Vickers, M. H., Sloboda, D. M., & Mora, H. A. (2012). Multi-dimentional connections: the Liggins Education Network for Science. In B. France & V. Compton (Eds.), *Bringing communities together: connecting learners with scientists or technologists* (pp. 161-174). Rotterdam: Sense Publishers.

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

Boyatzis, R. E. (1998). *Transforming qualitative information: Thematic analysis and code development*. Sage.

Bull, A., Gilbert, J, Barwick, H, Hipkins, R, Baker, R. (2011). Inspired by Science: A paper commissioned by the Royal Society of New Zealand teh th Prime Minister's Chief Science Advisor. In P. D. Gluckman (Ed.), *Looking Ahead: Science Education for the Twenty-First Century, A report from the Prime Minister's Chief Science Advisor*. Auckland, New Zealand: Office of the Prime Minister's Science Advisory Committee.

Bybee, R. W. (1997). Towards and understanding of scientific literacy. In W. Grabe, and Bolte, C. (Ed.), *Scientific Literacy – an international symposium*. Kiel, Germany: IPN.

Chin, C., & Osborne, J. (2010). Supporting Argumentation Through Students' Questions: Case Studies in Science Classrooms. *Journal of the Learning Sciences, 19*(2), 230-284.

Chu, C., Abella, I. S., & Paurini, S. (2013). Educational practices that benefit Pacific learners in tertiary education. Wellington. *Ako Aotearoa*.

Douglas, A. R., & Rodger, W. B. (2014). Scientific Literacy, Science Literacy, and Science Education. *Handbook of Research on Science Education: Routledge*.

Grace, M., & Bay, J. (2011). Developing a pedagogy to support science for health literacy. *Asia-Pac Forum Sci Learn Teach, 12*(2), 1-13.

Halapua, W. (2008). Moana methodology: A way of promoting dynamic leadership. http://sites.google.com/a/nomoa.com/talanoa/Home/papers-presentations/halapua-moana Retrieved 24 October, 2015

Hipkins, R., Bolstad, R., Boyd, S., & McDowall, S. (2014). *Key competencies for the future*. New Zealand: NZCER Press.

IBM Corp. (2015). IBM SPSS Statistics for Macintosh, Version 23.0: Armonk, NY: IBM Corp.

Kahn, S., & Zeidler, D. L. (2016). Using our Heads and HARTSS*: Developing Perspective-Taking Skills for Socioscientific Reasoning (*Humanities, ARTs, and Social Sciences). *Journal of Science Teacher Education, 27*(3), 261-281

Kawalkar, A., & Vijapurkar, J. (2013). Scaffolding Science Talk: The role of teachers' questions in the inquiry classroom. *International Journal of Science Education, 35*(12), 2004-2027.

Laugksch, R. C. (2000). Scientific literacy: a conceptual overview. *Sci Educ, 84*(1), 71-94.

Lawson, A. (2003). The nature and development of hypothetico‐predictive argumentation with implications for science teaching. *International Journal of Science Education, 25*(11), 1387-1408.

Lee Hang, D. M., & Bell, B. (2015). Written formative assessment and silence in the classroom. *Cultural Studies of Science Education, 10*(3), 763-775.

Lumpe, A. T. (2007). Research-Based Professional Development: Teachers Engaged in Professional Learning Communities. *Journal of Science Teacher Education, 18*(1), 125-128.

McCambridge, J., Kypri, K., & Elbourne, D. (2014). Research participation effects: a skeleton in the methodological cupboard. *Journal of Clinical Epidemiology, 67*(8), 845-849.

McIntyre, A. (2008). *Participatory Action Research. SAGE Publications, Inc.* Thousand Oaks, CA: SAGE Publications, Inc.

Millar, R. (2008). *Taking scientific literacy seriously as a curriculum aim.* Paper presented at the Asia-Pacific Forum on Science Learning and Teaching.

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.

Millar, R., & Osborne, J. (1998). *Beyond 2000: Science education for the future: A report with ten recommendations.* King's College London, School of Education.

Ministry of Education. (2007). The New Zealand curriculum for English-medium teaching and learning in years 1-13. Wellington: Learning Media Ltd.

Ministry of Education and Training. (2012). *The Tongan Education Lakalaka Policy Framework.*

Molnar, A., Boninger, F., & Fogarty, J. (2011). The Educational Cost of Schoolhouse Commercialism: Commercialism in Education Research Unit, National Education Policy Center.

Nutbeam, D. (2000). Health literacy as a public health goal: a challenge for contemporary health education and communication strategies into the 21st century. *Health Promot Int*, *15*(3), 259-267.

Nutbeam, D. (2008). The evolving concept of health literacy. *Social Science & Medicine, 67*(12), 2072-2078.

Organisation for Economic Co-operation and Development (OECD), (2013). PISA 2015 draft science framework. Paris: Organisation for Economic Co-operation and Development.

Osborne, J. (2007). Science education for the twenty first century. *Eurasia Journal of Mathematics, Science & Technology Education, 3*(3), 173-184.

Quanchi, Max (2004) Indigenous epistemology, wisdom and tradition; changing and challenging dominant paradigms in Oceania. In Bailey, C., Cabrera, D., & Buys, L. (Eds.) *Social Change in the 21st Century Conference, Centre for Social Change Research*. Retrieved from http://eprints.qut.edu.au/630/. 10 March, 2016.

Stoll, L., Bolam, R., McMahon, A., Wallace, M., & Thomas, S. (2006). Professional Learning Communities: A Review of the Literature. *Journal of Educational Change*, *7*(4), 221-258.

Taylor, E. W. (2011). Fostering Transformative Learning. In J. Mezirow, & Taylor, E. W. (Ed.), *Transformative learning in practice: Insights from community, workplace, and higher education.*: John Wiley & Sons.

Timperley H. (2011). A Systems' View of Changing Trajectories of Learning. In J. Parr, Hedges, H., May. S. (Ed.), *Changing trajectories of teaching and learning*. Wellington, New Zealand: NZCER Press.

Tonga Department of Statistics. (2011). *Tonga 2011 Census of population and housing: Volume 1: Basic Tables and administrative report.* Nukualofa.

Vaioleti, T. M. (2006). Talanoa Research Methodology: A developing position on Pacific research. *Waikato Journal of Education, 12*(15), 21-34.

Weinbaum, A., Allen, D., Blythe, T., Simon, K., Seidel, S., & Rubin, C. (2004). *Teaching as inquiry: Asking hard questions to improve practice and student achievement*. Teachers College Press.

Zeyer, A., Dillon, J. (2014). Science | Environment | Health—Towards a reconceptualization of three critical and inter-linked areas of education. *International Journal of Science Education, 36*(9), 1409-1411.

Copyright (C) 2016 EdUHK APFSLT. Volume 17, Issue 2, Article 10 (Dec., 2016). All Rights Reserved.