

# LENScience

## *Bringing Schools and Scientists Together*

# Scientists in High School Classrooms via Interactive Television

## Research Report

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Exploration of the use of ICT's to provide effective teaching and learning experiences is a key goal for Liggins Education Network for Science. Specifically, it is envisaged that ICT's may provide a mechanism by which students from a range of geographic locations could be brought together for seminars designed to provide learning extension opportunities, and simultaneously increase student awareness of the work of NZ scientists. Following a concept trial in 2007 using simple data conferencing technology, a further concept trial using either interactive satellite television or multicast technology was launched in 2008. The results of these trials have shown that the concept of bringing students from a wide range of schools together for advanced seminars linking NZ science directly to the NZ curriculum and NZ national assessments is well received by both students and teachers; that communication of concepts to the student is most effective when pre-seminar readings are written by teachers in consultation with scientists, and seminar presentation is shared by teacher and scientist; that scientists appreciate the opportunity to communicate in this way with secondary students; that satellite television technology with interactivity via wiki and on-line chat provided effective communication for participant schools from a wide range of geographic locations both rural and urban, independent of the level of broadband capability in the school. Finally the trials have shown that students in the remote audience had an equivalent learning experience to students in the live audience.

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## Introduction

Information Communication Technologies (ICT's) have had a growing presence in science education over the past 20 years. ICT's have created enhanced access to information for teachers and students, and where rich ICT resourcing is experienced, have changed the way students conduct experiments and investigations. It is widely reported that the use of ICT's can be beneficial to the development of higher-order thinking skills (Ed and Ton, 2001; Valerie and John 1999; Wegerif, R. 2002). The New Zealand Curriculum (Ministry of Education 2007), as with many international curricula (Ministerial Council on Education, Employment, Training and Youth Affairs. 2008; Qualifications and Curriculum Authority 2007; HM Inspectorate of Learning 2007), places an emphasis on the potential that ICT's offer to support teaching and learning. Use of ICT's in NZ schools during the period of mid 1990's – mid 2000's tended to focus on provision of animations, access to information through the World Wide Web, simulated experiments and data manipulation in those schools that had adequate access to computers and the internet. More recently schools with rich ICT environments have added the use of video on demand, data loggers, digital microscopes and cameras, electronic text books and online assessments. While this level of resourcing is not the experience of most, even in schools with low levels of ICT resourcing, teachers have access for their students to numerous web sites that are providing static information, simulations, pod casts, and in some cases interactive learning activities. Many of these offer excellent support to traditional teaching environments, however all of these resources are in essence static and lack interaction between the school community and the community in which the information is produced and/or used.

If e-learning is to meet the expectation of the New Zealand Curriculum (box 1) to “open up new and different ways of learning” (Ministry of Education 2007), the potential of ICT's to create actual interactions between members of learning communities must be engaged by both schools and those communities which produce and/or use knowledge and skills that are relevant to student learning. Interactive broadcasting, Web2.0, video-conferencing and data conferencing, combined with actual desire on behalf of the learning communities to interact, could provide tools that would enable this vision to be fulfilled. This paper will report on the *development of the educational design and present an evaluation* of a pilot study conducted to examine the potential for the use of ICT's to allow a scientific research community to engage in learning activities with secondary school communities.

Learning occurs when a series of planned, interconnected experiences are developed that allow the learner to explore the relationship between their current perspective of the world and the concepts and perspectives being presented to them within the learning experience. This process is by nature relational. Contexts and relationships are seen as very important aspects of learning (Hipkins 2006). Social constructivism theory is centred on the concept that “*learners create knowledge in the context of and as a result of social interaction*” (Franklin and Harmelen 2007). Learning involves the acquisition of knowledge of culture (Wilcott 1991). Science has its own cultural constructs which are foreign to the majority of students, meaning that in order for learning to occur, students must have opportunities to engage with this culture (Aikenead 1996; Aikenead 2007). Each student will bring their own socio-cultural framework to the learning environment. The impact of the learning experience will be determined by the interactions of the student with the community of learners within this socio-cultural

### Box 1: E-learning and Pedagogy

*The New Zealand Curriculum* Ministry of Education (2007) p.36

.....E-learning (that is learning supported or facilitated by ICT's) has considerable potential to support the teaching approaches outlined.....

For Instance e-learning may:

- assist the making of *connections* by enabling students to enter and explore new learning environments, overcoming barriers of distance and time;
- facilitate *shared learning* by enabling students to join or create communities of learners that extend well beyond the classroom
- assist in the creation of *supportive learning environments* by offering resources that take account of individual, cultural, or developmental differences;
- enhance opportunities to learn offering students virtual experiences and tools that save them time, allowing them to take their learning further

Schools should explore not only how ICT's can supplement traditional ways of teaching but also how it can open us new and different ways of learning.

framework and the ability of the student to enter the sub-culture of science through this learning experience. Allowing students to engage with scientists in discussions that include the process of development of scientific thought and evidence will encourage students to develop understanding of how scientific communities operate.

A belief in the importance of rich content understanding was the driver that resulted in a heavily content based “practiced” biology curriculum in New Zealand schools during the mid – late 20<sup>th</sup> century (Bay 2009). Hipkins et al (2002) propose that even in modern NZ classrooms delivery of content to develop future scientists is the implicit driver of science teaching. The driver behind this pilot programme is not the development of increased content understanding, but rather the exposure of students to understanding of concepts of the nature of science that will enrich their potential to analyse and evaluate biological situations. It is centred on the precept that development of an understanding of the nature of science will allow students to explore how scientific knowledge is established and what underpins a scientific world view (Osborne 2006). Actual scientific data is central to each module, providing students with the opportunity to engage with science and see science as a “real world” activity.

Application of knowledge to explain biological situations as required for the NZ Scholarship examination (Ministry of Education 2007), demonstrates the ability of the student to actively engage their understanding of biological concepts in novel contexts. Contextual learning activities engage students in “*active use of developing scientific understanding*” (Rivet and Krajcik 2008). They are thought to provide students with a framework to connect their developing knowledge with real world situations. Active learning in multiple contexts is claimed to support the development of skills required for knowledge transfer (Collins et al 1991) and contextual instruction is shown to promote transfer of ideas to other contexts.

The interconnectedness of 21<sup>st</sup> century society impacts on both science and science education. Science is global, competitive and interdisciplinary (Zimm 2000) and the interconnectedness achieved through the net has impacted on the way the scientific community operates. The internet has seen the emergence of civilisation-wide knowledge building which school students can take part in with scientists through their ability to access other learners using the internet (Scardamalia & Bereiter 2006). However the 21<sup>st</sup> century secondary student is by definition a digital native whereas the majority of scientists and science educators are digital immigrants (Prensky 2001). While the digital native generation are capable of performing multiple operations simultaneously, and according to Prensky may even have acquired different ways of thinking, digital migrants without these same capabilities are designing learning experiences for this generation. This generation, characterised by high levels of digital networked literacy, social interactivity and a preference for instant responsiveness and media rich environments (Oblinger and Oblinger 2005), need learning environments which are neither familiar nor comfortable for some digital migrants. Web2.0 tools have the potential to provide such learning environments and to create spaces where interaction between scientific communities and students can occur, assisting students in the construction of knowledge and the development of understanding of cultural constructs. These tools also support student centred pedagogies such as group work, discussion, peer review, exploration of varying view points, and enhance the potential for interaction in the process of construction of knowledge and understanding. The provision of an interactive social environment through a wiki has the potential to aid social constructivist approaches to learning, “*providing mediating mechanisms between collaborating students and between students and teachers, particularly between students who might sometimes be working in different places and at different times*” (Franklin and Harmelen 2007).

## Context, Rationale and Research Questions

Science as an understanding of the natural and physical world, based on concepts of evidence is central to 21<sup>st</sup> century life. It underpins the well being of communities through its relationship to resource provision and management, health and well being, sustainability, technological development and the economy. While provision of education for scientific literacy is essential and often dominates school science and curriculum debate, married

with this must be opportunities through school science for the development of interest and understanding in students who have the potential to be future leaders in science. The NZ Scholarship Examinations (NZQA 2005) offer one such opportunity, providing a robust academic challenge for high achieving students. Approximately 3% of NZ students studying Biology at NCEA Level 3 are awarded NZ Scholarship and approximately 0.3% are awarded Outstanding Scholarship.

The Scholarship Biology Performance Standard requires students to *“analyse biological situations in terms of ecological and evolutionary principles and demonstrate integration of biological knowledge and skills”* Students are expected to *“use biological knowledge and skills to analyse biological situations and integrate ideas into a coherent response; and demonstrate perception and insight in the analysis and integration”* (Ministry of Education 2006) Perception and insight is defined in the standard as the ability to *“make connections, see interrelationships, view situations holistically, develop alternative hypotheses and explanations, use critical thinking in analysis, evaluate a range of perspective and extrapolate to determine implications and consequences”* (*ibid*). This, combined with the requirement of the standard for students to be able to *“use information in response to a biological situation”* presents significant challenge to students. Examiners reports comment on the inability of many students to *“answer unfamiliar resource-based questions and apply their knowledge to the question asked”* (NZQA 2007). This evidence, accompanied the difficulties that students experience in the transfer of concept understanding to new contexts, suggests that there is a need for students to be exposed to more contextual, resource-based learning experiences.

New Zealand schools typically offer learning experiences to develop the skills and understanding required for the NZ Scholarship examinations via a combination of standard Year 13 teaching programmes and voluntary extension programmes run outside class time. The authors believe that extension learning experiences for these students should ideally be contextualised in current scientific research and encourage discussion around links between the issues arising in the context, core concepts of science, the research process, research findings and their interpretation. In biology this would typically involve students being exposed to current research articles, or preferably articles written specifically for 16 – 18 year olds based on current research and exposing students to actual research data.

The learning opportunities provided for extension of scholarship level students are also valuable to the larger percentage of students (approx 18%) who reach merit/excellence achievement levels in the NZQA NCEA Level 3 examinations. Major challenges for schools in the delivery of such experiences relate to both the time required to develop these types of resources, access for teachers to academic journals (this is negligible in NZ schools), and the ability of science teachers to engage in discussion with scientists about recent developments in science knowledge. Small schools are faced with additional challenges. Class sizes in these schools can be as low as 6, making robust academic discussion at the highest level challenging when less than 4% of all students in NZ are expected to be performing at this level. Even in an average sized urban school with a Year 13 Biology cohort of 20 – 30 students, there is typically only going to be 1 student working at this very top academic level and potentially 4-5 working consistently at the merit / excellence level. Small schools often only have one specialist Biology teacher, making the production of resources exponentially difficult in a country where very few curriculum specific resources at this level are produced and distributed. While cluster groups are used well by some teachers to address these issues, lack of access to journals and scientists is not resolved.

The authors hypothesised that specialist secondary teachers based within a scientific research institute, with relevant pedagogical content knowledge and access to current scientific research, could use e-learning to develop a programme which would address issues arising in the provision of meaningful learning experiences for high ability biology students in NZ schools.

### *Specific Research questions:*

1. Does collaboration between Research Institute based teacher and scientist create a platform for the development and delivery of contextualised learning experiences which have the potential to extend academically able students?
2. Could a combination of Satellite TV and Web2.0 tools be used to develop a model for New Zealand schools with poor broadband capability and generally poor ICT resourcing, which could enable students from geographically diverse locations to engage in actual rather than static interaction with science and members of a scientific research community?
3. Do students in the remote audience, participating via the use of ICT's have an equal or different learning experience to students in the live audience?
4. Can interactivity between individual students and scientists be created via the use of wiki
5. Can the combination of use of shared learning resources, shared live experience of the seminar plus wiki interaction create an environment in which interaction between students from a range of learning communities is achieved?

### Methodology

A design research model (Reeves et al 2005) was used to explore the development and effectiveness of an e-learning design to create a learning environment which allowed students from a diverse range of geographical locations to engage in actual interaction which supported construction of understanding.

The 2008 pilot programme evolved as a result of a series of trials used to develop and test the potential to use ICT's to enable actual, non-static learning interactions between schools and scientists over a period of two years within the Liggins Education Network for Science<sup>4</sup>. Five major developmental steps were undertaken leading up to the pilot trial of the satellite TV –wiki technology model:

- i) development and trial of the education model base on student reading modules linking current research data to concepts in Level 8 of the NZ Curriculum and designed for students in the top 30% of the academic spectrum
- ii) professional development for teachers relating to the research being used in the student modules
- iii) professional development for scientists to enable understanding of the school curriculum and appropriate teaching styles, leading to the development and trial of seminar presentations co-presented by teacher and scientist
- iv) writing of a wiki site to provide a pre and post-seminar discussion environment
- v) development and testing (both in the Institute and trial schools) of the technology architecture required to enable the pilot trial to proceed

Anonymous questionnaires (open and closed questions), researcher observation and reflection, evaluation of seminar recordings, and evaluation of wiki interactions were used in the analysis of the 2008 pilot. Students, teachers and school ICT technicians (or teachers with responsibility for ICT) participated in the questionnaires. Analysis of variance using a hierarchical model was used to analyse difference in question response between the live and remote audiences.

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<sup>4</sup> The Liggins Education Network for Science (LENS) is a secondary science education unit within the University of Auckland's Liggins Institute. LENS was formed in June 2006 to fulfil a vision of the Liggins Institute and NRC DG to provide effective links between secondary schools and scientific communities in the area of biomedical science. Learning modules are designed by collaboration between specialist secondary teachers and scientists, linked to the NZ curriculum and contextualised within current New Zealand science.

The educational model developed consisted of a partnership between the participant schools, Institute teacher and scientist in which satellite television technology was used in combination with Web2.0 tools to provide actual interactions between students, scientists and teachers through a series of 3 seminars contextualised in current scientific research and linked to the school curriculum. Pre-seminar readings were provided for students; seminars were co-presented by teacher and scientist; live question time enabled students and scientist to interact in real time; post seminar challenge questions were presented to students and wiki used to engage in discussion around these between students, teachers and scientists.

## Design Process

### The development of the education model

The Institute based teachers who designed the concept and developed the educational model have significant sector leadership experience at a national level, providing knowledge of the perceived needs of New Zealand Biology teachers around teaching and learning programmes for advanced learners in Year 13 Biology classes. Development of the model utilized a combination of this knowledge with evidence from developmental trials carried out in the Institute's classroom, pedagogical content knowledge, and input from teachers and scientists representing stakeholders. Learning modules were designed in contextualised format making links between issues in society (relevance of science / capture of student interest), the science, and concepts in the curriculum. Development of understanding of the nature of science underpinned each module via exposure of students within the readings to concepts relating to development of scientific evidence and theory. Scaffolding of concept development within each module moved students from concept reinforcement to exploration of evidence and extension. Details of the learning materials can be found in the supporting on-line material (SOM)<sup>5</sup>.

**Box 2 Learning Modules and Curriculum Links:**

Module	Curriculum Concepts	Contexts
1. Feast or Famine: The impact of environment on gene expression	Gene Expression Processes of Evolution Nature of Science	Developmental Programming / Early Puberty / Adult Disease
2. Breast Cancer & Biotechnology	Molecular Genetics Mutations Applications of Biotechnology Nature of Science	Breast Cancer
3. Walking Upright: The Cost of Human Evolution	Processes of Evolution Trends in Human Evolution Nature of Science	Social interaction Technological Development Reproductive Costs

All resources were co-authored by teacher and scientist, each bringing their specific expertise into the process to ensure that these were scientifically accurate and capable of engaging high school students in the development of concept understanding and higher-order thinking skills, including the ability to apply knowledge to analyse biological situations which they have previously not encountered. Teaching trials in the Institute classroom during 2007 showed that learning activities based on contextualised, co-authored resources linking scientific research with concepts in the school curriculum had the ability to engage students in learning which students and teachers valued. Students reported that these activities were enjoyable to participate in and assisted them to develop understanding of curriculum concepts (n=770). Teachers whose classes participated in these trials reported student initiated re-engagement of the class with these contexts up to 6 months after the class had experienced the learning activities in the Institute (*Bay, unpublished data*). This evidence was used to establish that contextualised learning resources and the contexts selected would provide engaging learning in a face to face environment that could assist students to develop understanding.

<sup>5</sup>Supporting Online Material <http://lens.auckland.ac.nz>

### Genre of the seminar papers.

While intentionally not written in the style of a scientific paper, the student seminar papers in this model do present actual research data, encouraging students to explore evidence and analyse biological situations. Student readings using a classical research article genre have been shown to have a place in the development of understanding of the activities and communication modes of biologists and the nature of science (Baram-Tsabari and Yarden, 2005) and to encourage students to ask questions (Brill and Yarden, 2003). However it is also reported that readings presented in the format of traditional research papers pose difficulties for students due to their “*lack of schemas and automation that expert readers process and activate during their reading of articles*” (Brill et al 2004). Given that the proposed learning environment in the trial was presenting students with new challenges around interacting with scientists, and working in a Web2.0 environment, it was decided not to use a traditional research paper structure in the seminar paper, adding a further unfamiliar aspect to the learning environment. Rather a narrative structure was used which established student interest via context, made clear links in the early section of the paper with concepts familiar to the students, presented evidence from published scientific research, leading to discussion that aimed to assist students to make meaning of the evidence that was presented. Developmental trials in both the Institute classroom and school classrooms with papers of this style provided evidence suggesting that the presence of actual data encouraged discussion and analysis of evidence by the students

*“.....my class became obsessed with the real data – they ended up spending an entire period analysing and discussing what the evidence presented meant.....”* (Year 13 teacher).

The scientific research contexts that were used in all three seminars had been presented within LENSscience teacher professional development symposia in the 2 years leading up to the pilot. At each of these symposia teachers were provided with related scientific papers and the opportunity for discussion of the science with key scientists from the research groups. This had offered the opportunity to check that a wide range of biology teachers ( $n > 200$ ) perceived these contexts to be relevant in engaging students in the development of understanding of concepts in the school curriculum, and that the scientific papers provided for the support of teachers’ understanding of the research were accessible and useful for teachers.

The key scientists involved in the programme were fully briefed on the NZ curriculum, learning outcomes expected in Year 13 biology courses, assessment expectations of both NCEA Level 3 Biology and NZ Scholarship Biology, and appropriate teaching strategies for Year 13 students. They all had significant experience of interaction with Year 13 students and teachers during the two year period that led up to the pilot. This involved a combination of observation of teaching by the Institute’s secondary teachers, small group interaction with students in secondary classes within the Institute classroom, teaching to secondary students via seminars developed in conjunction with teachers, and science education symposia presentations and discussions with teachers about their research. Informal reflective critique discussions between the scientists and teacher-author were used during this time.

The core of the education model design was consistent throughout the two year development period leading up to the pilot study. This consisted of a learning partnership between the school and the Institute in which:

- a seminar paper, co-written by teacher and scientist, and associated teacher authored learning resources were pre-distributed to schools
- students were encouraged to read and discuss the seminar paper with their peers before the seminar
- students had the opportunity to pre-ask questions before the seminar
- the seminar was presented via live broadcast, after school hours to both live and remote audiences
- both the live and remote audiences had the opportunity to ask questions and interact with the scientist, teacher, and audience

During the developmental period leading to the 2008 pilot the following amendments were made to the format:

- co-presentation by teacher and scientist of the seminar was initiated and shown to improve concept linking for students and add teaching that supported development of students ability to analyse biological situations and construct extended answers to examination style questions
- students were provided with a list of core concepts from the Year 13 biology programme and advised to review these prior to the seminar in order to assist students to make links between these concepts and the scientific evidence
- at the end of the seminar students were presented with challenge questions designed to encourage the development of their ability to analyse biological situations with “perception and insight”
- a wiki site was developed to allow students easy access to resources and provide a means by which students from participant school could connect in post-seminar discussion.

### Development of the technology architecture

The pre-pilot trials in 2007 involved the delivery of one seminar (module 2 version 1) on two different occasions. Twelve schools geographically diverse schools participated with a live local school audience. SMART Bridgit Conferencing Software, in conjunction with a teleconference, was used to link schools with the seminar. Connection trials in advance of the seminars showed that dependent on the time of day, in some schools there were delay issues upwards of 2-4 minutes. This was identified as an issue caused by the contrast in upload and download speeds between the participant schools and the university. Trials between computers within university networks at similar bandwidth speeds were found to be faultless. Web cameras were removed from the setup to reduce the delay and while in some schools there was a constant and good delivery of the data conference, others found visual delays to be extensive (>5 minutes). Despite the technological issues all participant schools reported that they would like to see the programme developed and would be interested in participating in further trials.

Evidence from a related LENSscience project which used web-casting to deliver lectures by international scientists to NZ schools identified that even with high quality web-cast designed to broadcast to networks that may only have bandwidth equivalent of home broadband, a number of schools experienced issues relating to delayed and disrupted connections. This confirmed for us that any form of web-casting was likely to produce significant issues for many participant schools. At the time of the trial fewer than ten secondary school were connected to the high speed research and education network (KAREN).

Using this evidence, a system of delivery was developed that overcame these issues. The system used Kordia™’s content services, linking and satellite technology in combination with Telephone Bridge, Skype chat room and a wiki site provided by the University of Auckland. The seminars were produced by VoltTV Productions and broadcast to five secondary schools in a range of geographic locations, both urban and rural. In addition, the broadcasts were transmitted to two schools in the Wellington region via the KAREN network. Schools receiving the broadcast via satellite were supplied with the technology required (a set-top box and satellite dish). Each school supplied a television (most connected these to data projectors for large screen viewing), phone line and computer to access Skype and the wiki.

### Pilot Trial of Educational Model Utilizing the Satellite TV –Wiki Technology Design

The pilot trial, although developed over a period of two years, came to fruition at very short notice due to satellite service availability. Schools were advised of the potential to participate only 3 weeks in advance of the trial which was held in the 4 weeks prior to national examinations in NZ schools. This created less than ideal timing; however a decision to proceed was based on the need to assess and the potential of the technology prototype before a full evaluation of the learning environment impact. A full evaluation of the educational benefit will occur in 2009, once all aspects of the technology involved are confirmed following the findings of this trial.

The pilot audience participating in the evaluation consisted of students from 10 schools, 5 via satellite TV and 5 in the live audience. An additional 10 schools participated in the event by joining with remote audience schools or via

the KAREN network but did not participate in evaluation. The teachers in 3 of the 5 remote audience schools and all 5 of the live audience schools had all attended professional development relating to all three research contexts. Between 100 and 130 students each week chose to participate in the voluntary questionnaires which were conducted at the conclusion of each seminar. 80% of teachers participated in the questionnaires.

The provision and installation of the required technology in the 5 remote schools removed any variation in the quality of the broadcast that was received in the schools. The provision of paper copies of the learning resources to each school ensured that students had access to these materials. The findings are based on the following assumptions about the participants which could not be controlled and have not been measured:

- that the remote and live student population had all experienced a similar course of work in Year 13
- that there was no significant difference in the academic ability of the remote and live audiences
- that teachers in the trial shared a similar level of knowledge of concepts in the Year 13 biology curriculum

## Results and Discussion

### *Participant Community Demographics*

The analysis of participants in the questionnaire (Figs 1 – 3) suggests that those students choosing to participate in the questionnaire created a representative group in terms of school size and location. The ethnic distribution in the sample is not representative of the NZ student cohort, lacking significant Pasifika representation and having a lower than desired Māori participation. These two groups are underrepresented in science cohorts at Year 13 in NZ schools. The large proportion of females in the group resulted from a dominance of large single sex girls' schools geographically very close to the Institute who comprised the majority of the live audience. 85% of participants intend to enrol in science courses at university on leaving school, indicating that this voluntary programme was attracting students for whom a career in science was a real possibility. Analysis of the data via ANOVA indicates that the population of students responding to the questionnaires is homogenous for each of the three seminars.

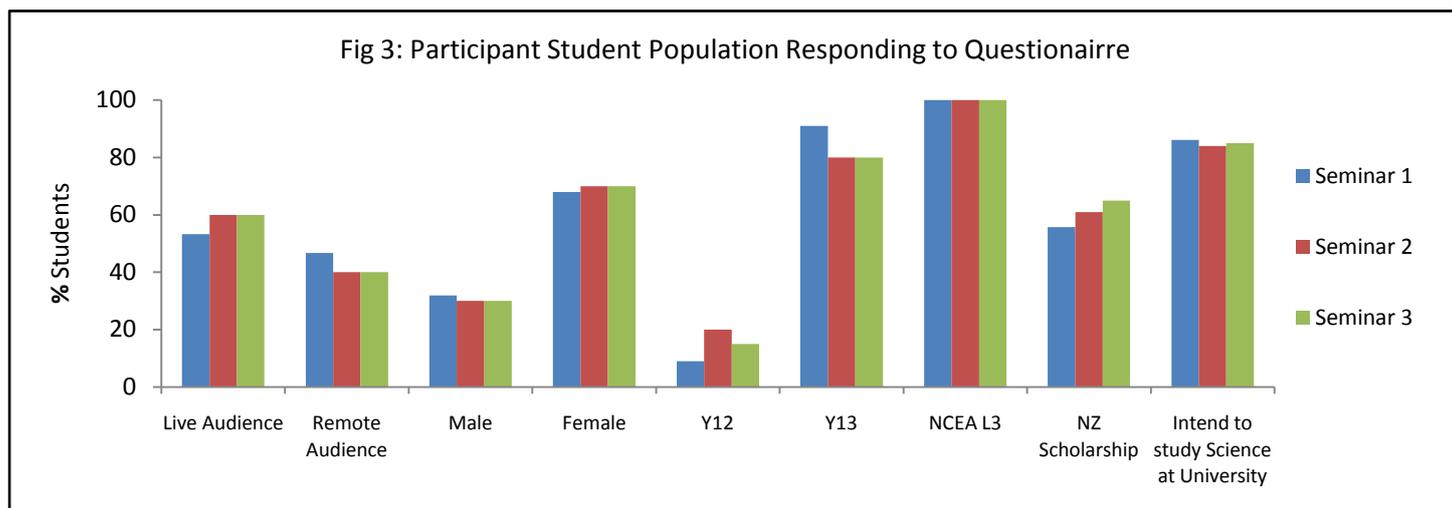
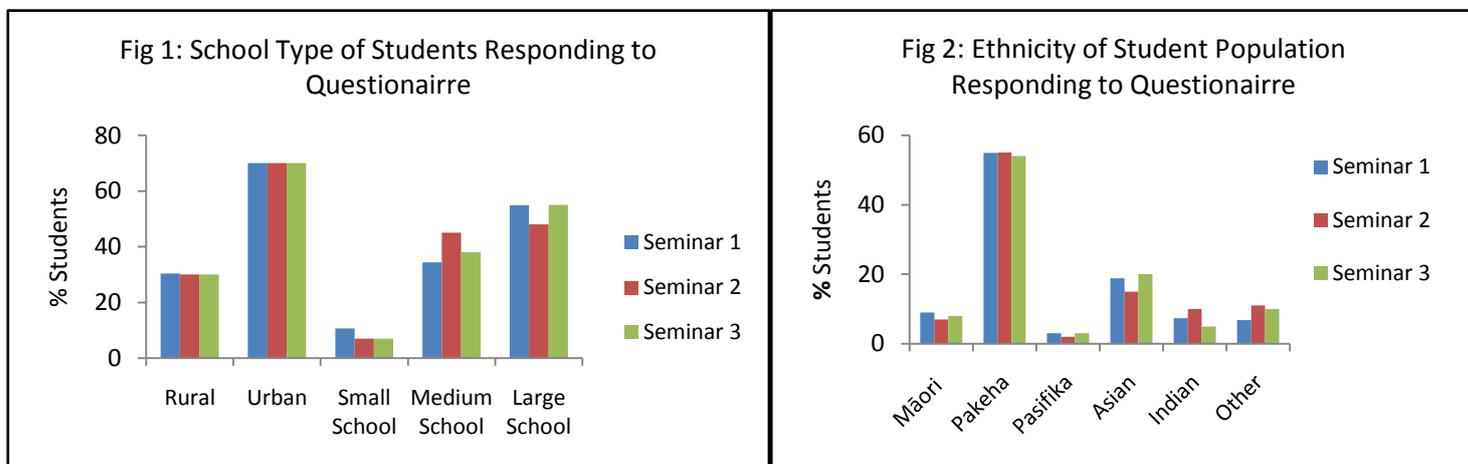
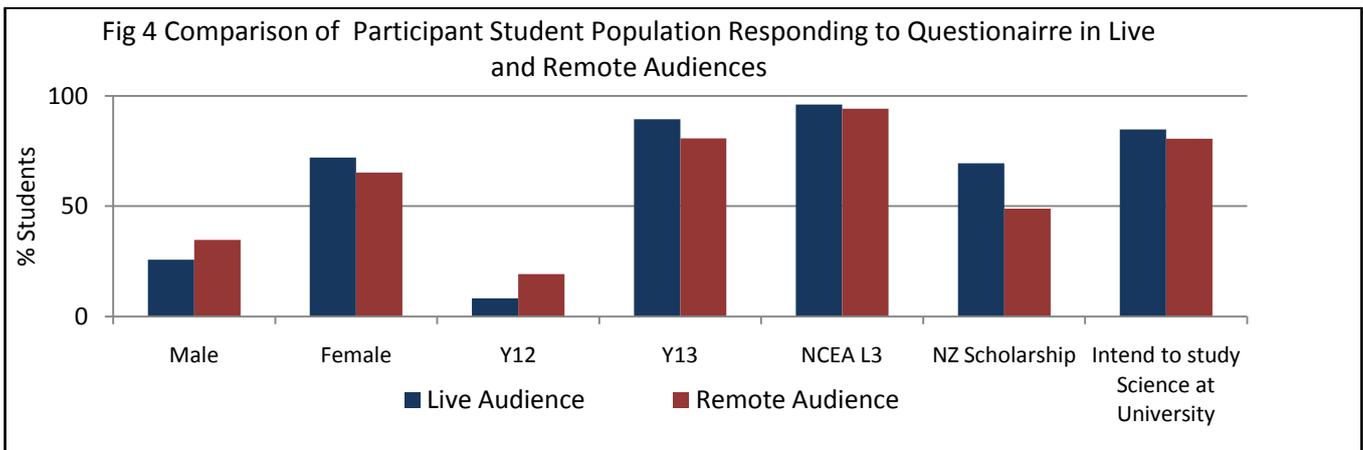


Figure 4 indicates that the only area of significant difference between demographic of the remote and live audience is in the proportion of each of these groups that were intending to sit the NZ Scholarship examination ( $p=0.002$ ).

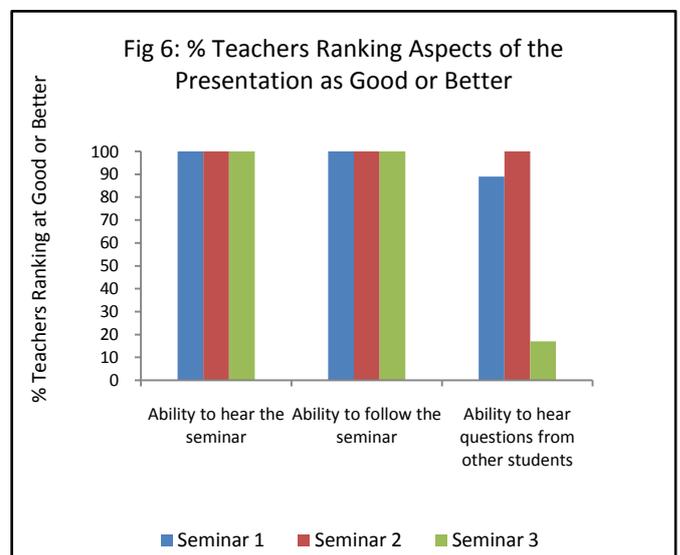
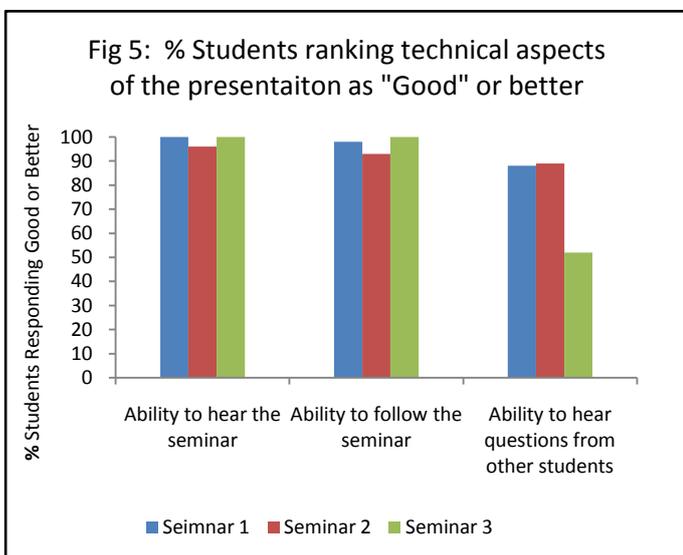


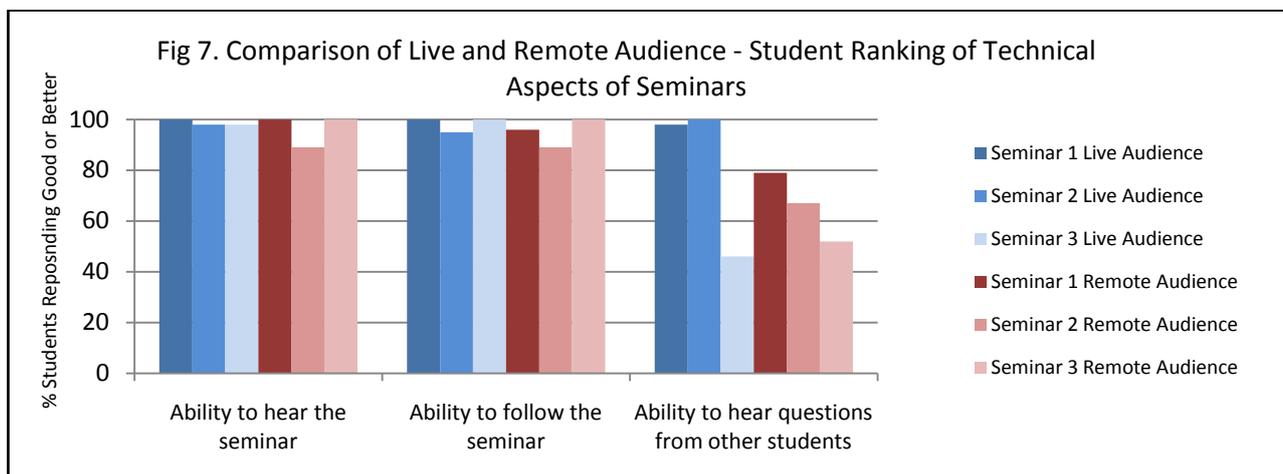
Did the technology model used meet the need?

The 2007 trials identified the need to find an alternative to web based broadcast in order to overcome issues of lack of broadband capacity in NZ schools. Questioning of IT technicians or teachers with that responsibility regarding the ability to connect and equipment required for the satellite broadcast indicated that no major difficulties arose. Rather surprise at the ease at which they could participate was reported.

*“It really was just turning on a TV and there you were” (Participant IT technician remote school).*

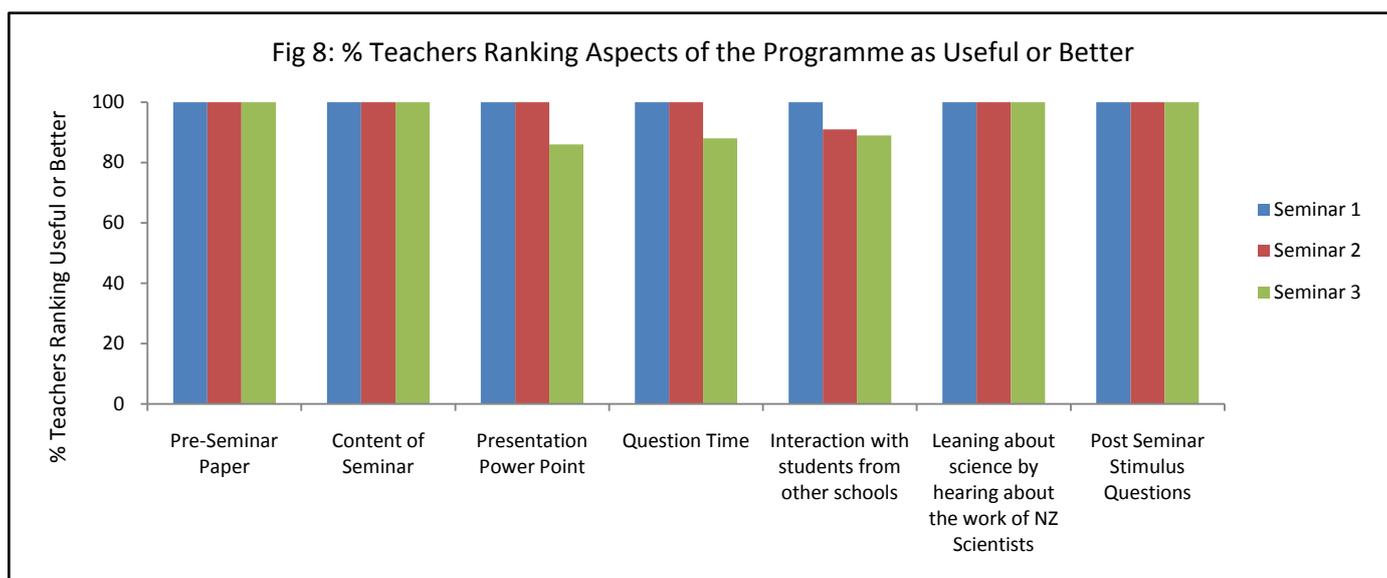
Participating students and teachers also reported on technical aspects of the seminar. All groups noted the problems associated with sound through the phone links to schools, particularly in seminar 3. This issue related to sound feedback and led to the decision not to use phone as a means of communication in the model. Comparison of the experience of students in the live and remote audience indicated that in every seminar, the remote audience students experience relating to the ability to hear questions was inferior (Fig 7). Teachers and IT technicians suggested that the private Skype chat room provided a good mechanism for questioning during the seminar. Responses indicated that they believed this to be both technically effective and a more comfortable mechanism for students to use. It was recognised by the IT architects that Skype, while effective with a small group of users would not cope when the trial was taken to scale. A live-chat component was added to the wiki site in place of the Skype chat room and is being trialled in the 2009 study.



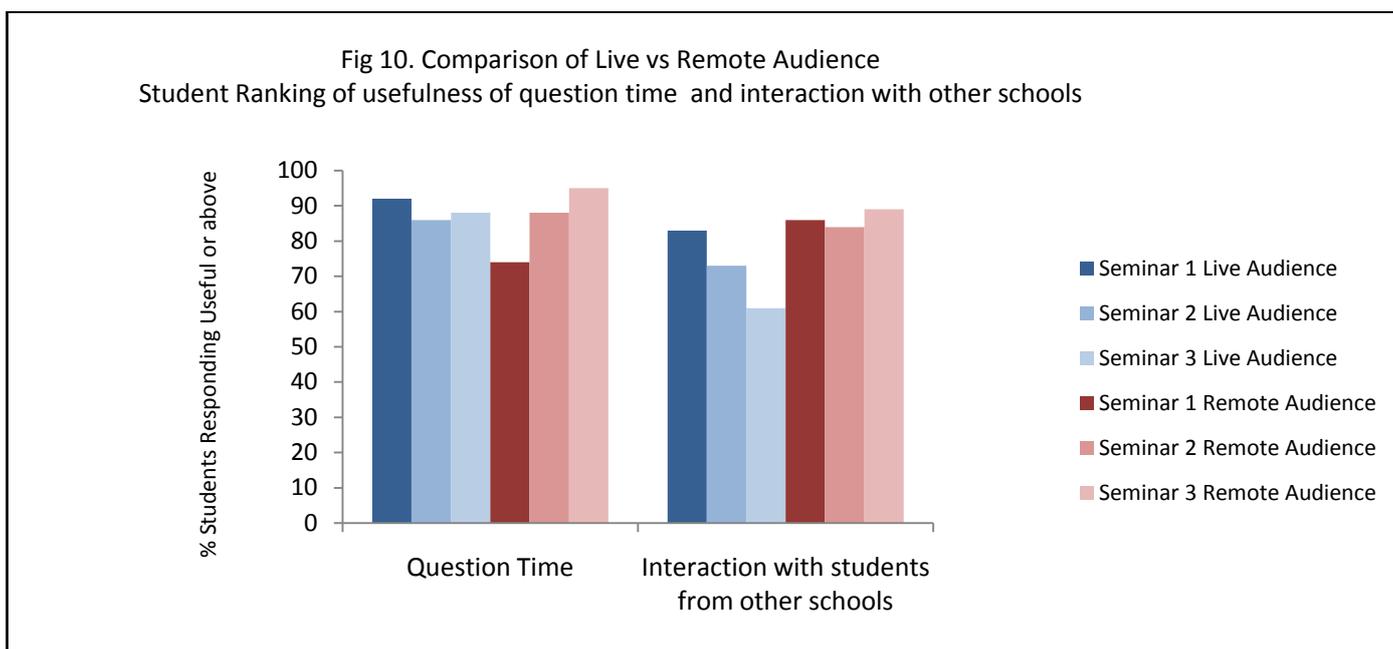
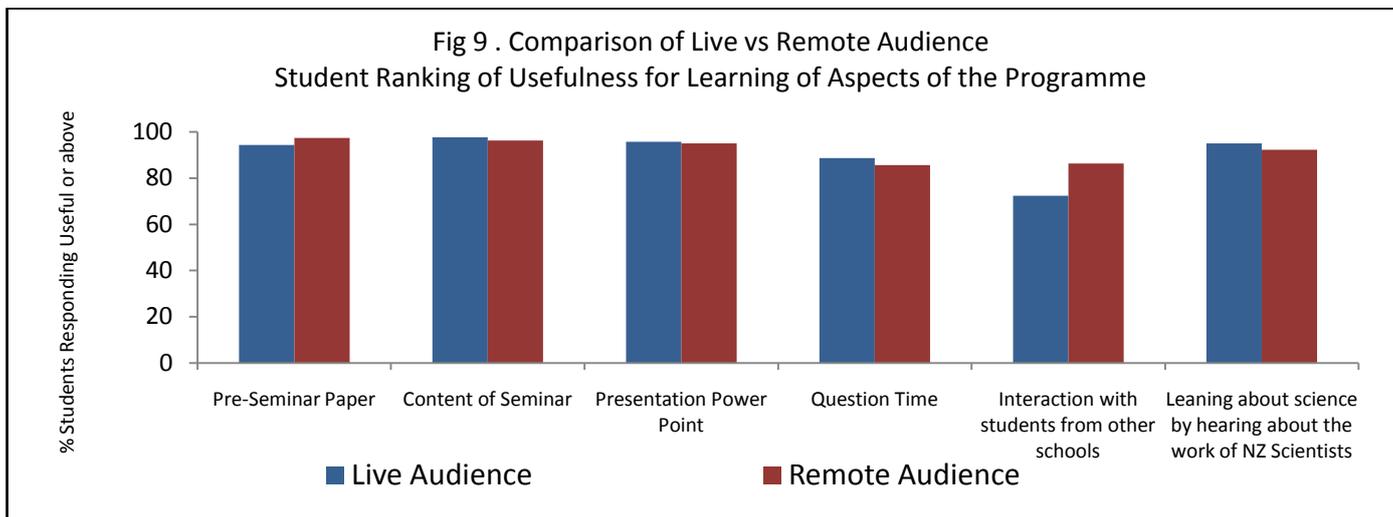


*Value and relevance of the learning experiences*

Both students and teachers indicated that they valued the learning experiences offered. The project team acknowledge that the tight time frame resulted in inadequate time in some cases for pre-reading to occur. This is to be addressed in a full trial which will run over a period of a year and include a more formal pre-seminar programme that will be undertaken in schools involving pre-reading and focus questions. A likert scale was used to rank usefulness for learning. All participating teachers indicated that they had valued the experience and would definitely participate in future programmes. 90% of students responding to the question indicated that a programme such as this earlier in the year would have been beneficial to learning.



A comparison of the student responses in the live and remote audience was used to ascertain whether there were significant differences in the experience of these groups. On analysis by hierarchical ANOVA, a significant difference was seen in the perception of the students in the two groups of the value of post presentation question time and ability to participate in interaction with students from other schools.



Students and Questions

Overall there was a high level of value seen in the question time with between 80 and 90% of students ranking it as useful or very useful. Analysis of the value of post seminar questions time using an Analysis of Variance hierarchical model indicates that there is a significant difference between the responses of the live and the remote audience  $P=0.02$ . There is no significant difference in the responses **between** seminars for each type of audience. This supports the assumption that the 3 seminars delivered were of equal quality. The question this raises is the need to develop a more reliable way for students in the remote audience to ask and hear questions posed by other students.

Students in the first seminar were reluctant to ask questions, yet responses in the questionnaire to an open ended question asking for suggested improvements indicated that some students wanted a longer question time. Typical student responses included

*“It needs a longer question time”*  
*“It could have been longer and contained more time for discussion at the end”.*

Interestingly a number of students who asked for a longer question time indicated that they had not themselves asked questions. The concept of silent participants who value the interactions of others in a learning environment may be indicated by this (Beaudoin, 2002).

Students were asked whether they thought asking questions was easy or hard and why. Of those that responded, equal numbers reported easy and hard. Those that responded and thought it was hard to ask a question could be categorised into five groups:

- lacked confidence in a large audience
- needed more time to formulate the question
- other students asked the question
- found the content of the seminar difficult to understand so could not ask a question
- too busy taking notes about what others were saying / asking

Those that responded and thought that it was easy to ask a question could be categorised into two groups in terms of explanation of the ease of asking questions:

- good atmosphere / not patronising / were encouraged to ask
- interesting topics made it easy to ask questions

Throughout the three seminars it was noticeable that most students who did ask questions extrapolated from the information that had been presented, asking questions around the data, indicating that they were thinking beyond simply what was being presented. These questions supported the notion that the students were using higher order thinking processes to evaluate the information that was presented. An example of this is seen in the 1<sup>st</sup> seminar where information was presented on models that have been developed to assist scientists to understand the effect of early life environment (mother's diet in-utero), on adult phenotype. The student did not ask about the model that had been presented but asked if there was research looking at variations on this model and if so what their research had indicated.

The wiki clearly provided students with the ability to think about and develop quite extensive questions in advance of the seminar

*"If telomerase can prevent apoptosis by increasing telomere length in cancer cells and in eukaryotic germ cell, has there been research done on increasing life span of eukaryotic organisms and treating 'Progeria' with telomerase? Also what are the effects of telomerase on tissue regeneration and wound healing?"*

However, students asking questions on the spot also showed an ability to compose complex questions.

*"You spoke about how humans have evolved to live in smaller social groups, and you touched on how we now live in larger social groups. I was wondering how at our level, having schools in such large social groups as we have and in the stage of brain development that we are in (as teenagers). Do you think the large social groups could be detrimental to development?"*

Throughout the pilot scientists were surprised by the ability of students to ask questions that extrapolated from the data or evidence presented in the seminar, and the level of complexity of the questions that were asked. Teachers however, were less surprised by the complexity and breadth of the questions that students were asking. What this has highlighted to scientists is the complexity of the role that secondary teachers have, (a) in facilitating learning that engenders this level of questioning amongst students and (b) in responding to such questions on a daily basis across a wide range of science.

The majority of students were reluctant to ask questions. Further trials will explore mechanisms by which student confidence to question can be developed. The pre-seminar focus questions and in-school workshops planned for the next trial are one such mechanism. The technology choices of students will also be explored in this regard, focusing on the development of systems where students feel comfortable to question.

### Inter-school interactions

Overall there was a high level of value placed on interactions with students from other schools with between 80 and 90% of students ranking it as useful or very useful. Analysis of students perception of the value of this interaction using an Analysis of Variance hierarchical model indicated that there was a significant difference between the responses of the live and the remote audience  $P=0.03$ . There is no significant difference in the responses **between** seminars for each type of audience. The students from the remote audience report an overall higher level of appreciation of the interaction with students from other schools through the interactive seminar model. The remote schools were from a mix of large city; small city; regional town and small rural centre. The students in the live audience were all from schools within NZ's largest city, however 2 of the 7 schools within this groups were small schools with Year 13 biology cohorts of less than 15 students. No information from the open ended questions in the questionnaire could explain why this difference was seen. Further analysis of this question is required via interview to understand the reason behind the difference.

The highest level of effective inter-school interaction was seen in the Skype chat room where teachers and students from a number of schools joined in an on-line discussion during the seminar. The chat room was hosted by an experienced biology teacher from within the Institute and supported by an ICT help-desk expert. Analysis of these interactions showed that while initially they focussed on introductions and small talk, even before the seminar started students were asking questions about the seminar content. As the seminar progressed, students were asking and responding to questions arising from the seminar, thus interacting with each other. While the chat records from the trial system could not be captured, the teacher monitoring these sessions reported that by the 3<sup>rd</sup> session the chat looked very similar to that observed in the 1<sup>st</sup> of the next stage trials (box 3).

Evidence from the pilot trial suggests that the online chat is an effective way of allowing students to interact both with students from other schools and with the scientists to ask questions. The chat-system being used in the next stage of the trial will allow full capture and detailed analysis of these interactions.

```
15:37:38)Axxxxx_: hello
(15:38:27)Axxxxx_: ??
(15:38:30)Axxxxx_: anybody??
(15:38:58)Cxxxxx_: Hi Axxxxx
(15:39:20)Axxxxx_: hey cxx
(15:39:34)Axxxxx_: hows the weather there??
(15:39:53)Cxxxx_: Sunny ish ??
(15:40:46)yyyyyyy: wooo
(15:40:54)Jxxxxxx_: cool its raining here
(15:41:28) Cxx_ Hey Anna, cancer arises by mutations, why is this
not always picked up by the checkpoint? And... How does the
CDKs get out of control?

SEMINAR STARTED AT 14:50.....

(16:04:41) Cxxx_: What does cDNA mean?
(16:05:12) Nxxx_: Chromosomal DNA?
(16:05:37) Bxxxx_: complementary dna
(16:05:39) Dxxxx: cloned? copied?
(16:05:45) Cxx: ok
(16:07:46) Cxxxxxxx: thanksout (Timeout).
(15:44:02) Dddddd: What about the introduction of the human
growth hormone into the body from outside sources
```

Box 3: Example of transcript from online chat

### The use of wiki as an interactive learning tool

The wiki site was intended to increase accessibility for students to scientists, teachers, and students from other schools. Feedback has indicated that the majority of teachers and students are not familiar with the use of this type of Web2.0 environment in an educational setting.

*"I think that as confidences grow in the use of the technology, the students will be more responsive. I do hope that they will use Wiki, but I have to admit that I was a little confused to start with."*

One student who posted an extended discussion after the first seminar reported that she was discouraged by the fact that other students were not joining in and had felt she could not write more until the community grew larger. Teachers reported that students were *"waiting for someone else to go first"*

Despite this, 70 users became members of the site and seven contributed to the discussion. The timing of the project during final examination preparation for students may have contributed to lack of active participation in the wiki. Questioning of teachers involved in the trial indicated that none had experience with wiki either as members

of a wiki community or in the use of wiki in teaching and learning. Their responses to the wiki ranged from not touching it to attempting to use to actively encouraging student use. Some recognised that they had role in facilitating use of the wiki within their learning community.

*“The seminar was fabulous and came through loud and clear ..... I am showing students the wiki and how to access it tomorrow.....”*

A small group of students from one school in the remote audience had an English teacher who had been using a “closed wiki” with the class during the year. The students in this group commented that the wiki associated with this programme was more challenging as it was “*visible to the public*” rather than just to members of the class.

It would appear that this level of wiki use and experience is not unusual in NZ schools. Approximately 100 teachers attending 5 meetings to inform schools of the initial findings of this trial in a range of small and large centres were questioned on this issue. One 1<sup>st</sup> year newly qualified teacher was intending to use a wiki with his classes and one other teacher (less than 5 years experience) was thinking about developing a wiki to use in teaching. Only 3 teachers other than these had ever engaged in a wiki community. There is a clear need for confidence in teachers to either use the wiki or to engage students who are confident users to instruct the class in how to use the wiki.

Understanding of how to log-on and use a wiki, along with the public nature of this environment presented a barrier to use of the wiki. Recommendations for the next phase of the trial include increased instruction for teachers in the use of the wiki, encouraging schools to submit discussions as a group,s and the use of challenges to specific groups of students within the learning community to encourage engagement.

### *Students’ perceptions of overall value*

75% of students described their participation in the trial as a valuable learning experience. Four key recurring themes in explanations relating to this were each reported by more than 10% of respondents. These were relevance / links to the school curriculum; learning experiences beyond school/extension; academic challenge; increased motivation to revise; the experience providing them with better understanding of concepts.

Thirty students, of which nineteen sat the scholarship examination, responded to a questionnaire that was distributed after the national examination period had been completed. These students were asked to comment on the usefulness of the series for development of understanding and preparation for the Level 3 and Scholarship examinations. The majority of answers reflected the same themes as the pre-examination questionnaire with explanations from more than half the respondents fitting with the themes stated above and 11 out of the 30 students commenting that the seminars held a high level of interest for them.

The students were also asked to comment on whether a longer series would be useful. All but one responded positively to this. The student who responded negatively had not sat the scholarship examination. Twenty-five students provided comments which clustered into two basic responses. The main group talked about the helpfulness of being able to cover more topics over the full year; a second small group of 5 students talked about the benefits of an alternative method of learning and the ability of the seminars to provide them with access to learning that could not happen in class

*“.....more in-depth information and discussion on Bio, that is not able to be discussed in class...”*  
*“another method of learning was interesting”.*

One student suggested that it could encourage more students to attempt the scholarship examinations

*“it was interesting and motivating..... it may encourage more students to attempt scholarship”*

A recurring theme in national examiners reports is the inability of students to respond to questions that require application of knowledge to biological situations which are novel to the student. In the introduction to the seminar series students were reminded that in order to gain these skills they need to be exposed to experiences where they are required to apply their knowledge to novel situations and that the seminars wee designed to provide such experience. While 9 of the 19 students in an open ended comment request remarked on the direct help that they believed the experience gave them in coping with the questions in the scholarship examination, 3 of the 19 wrote comments which indicated that they did not understand that the contexts presented in the seminars would not be the contexts presented in the examination

*“the cancer seminar was a waste of time, there was no question in the exam on biotechnology”*

*“ the topics for the seminar were different to the topics in the exam”.*

These responses reinforce the need for students to understand the difference between concepts and contexts and for teachers to engage in repeated active discussion with students regarding the expectation that they will face examination questions in which they are required to demonstrate their ability to apply concept knowledge to novel situations.

## Conclusions and recommendations for future development

The project set out to find a mechanism by which academically able students could interact with scientists and other students in a learning experience which would provide a context in which there was the potential for students to engage with the culture of science and through this develop increased understanding of science. The model of collaboration between teacher and scientist in development and delivery of learning programmes has been shown to be effective. The addition of a strong relationship with teachers in the school and teachers within the University is beneficial and will be developed further in future trials. The technological solution developed has demonstrated that the use of satellite television can alleviate the problems arising from access to adequate bandwidth in many schools. The trial demonstrated that online chat is a more effective way to create interactivity within this setting for remote audiences than telephone. While Web2.0 wiki tools have the potential to create a community of learners, and allow students to interact directly with scientists, significant barriers are presented by the lack of knowledge and experience with wikis of NZ secondary teachers and students.

Students participating in the seminars via the remote audience reported the same experience as students participating in the live audience in all aspects of the trial apart from the ability to hear questions and their perception of the value of interactivity. The issue around hearing of questions is to be addressed through identification of on-line chat as the preferred technology for interaction. The higher level of response to remote audience students regarding interactivity with students from other schools is to be further investigated.

The trial showed a glimpse of the potential for on-line chat and wiki to enable students from a range of schools to join with scientists and create an interactive on-line community. The timing of the trial limited ability to effectively test this hypothesis. The 2009 full year trial results are required to answer this question.

The following recommendations are suggested to increase the effectiveness of this programme of learning:

- as increase in the number of seminars and time between seminars in order to allow development of concept understanding across all aspects of the curriculum and create the ability for learning relationships to form
- the provision of learning resources to support schools to provide pre and post seminar workshops to encourage the collective development of questions and discussion
- the development of an on-line chat facility within the wiki that will cope with a high volume of traffic
- the change from phone to on-line chat to only on-line chat to provide interaction between remote audiences and the seminar
- the provision of increased support to teachers in the development of Web2.0 skills
- the use of web based newsletters to increase interaction between Institute teachers and schools (both teachers and students)

The internet has seen the emergence of civilisation-wide knowledge building which school students can take part in with scientists through their ability to access other learners using the internet (Scardamalia & Bereiter 2006). The context of the Institute and the meaningful engagement with scientists provides students with an experience that allows them to see into and engage with a scientific community and its culture. Further development trials are required to refine this learning model in order to maximise its potential.

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