



PRE-FIGURING THE 2020 NBN-ENABLED CLASSROOM

'ZOO-CONNECT', A CASE STUDY

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Central to discussions about NBN-enabled applications and services is the potential for innovative ways of learning, particularly in relation to online and interactive education. This paper reports on trials of the collaborative software tool Adobe Connect in NSW schools, and reports on two field studies for Zoo Connect, an interactive, multimedia, remotely-delivered class lesson. Results from the trials support those who advocate the NBN as a means to extend classroom learning, and provide evidence that may prompt educators to transition to virtual classrooms sooner rather than later. Recommendations are made for the wider development of NBN-style education programs, regardless of whether or not they fall into the early rollout category/regions, in order to fast track innovation, encourage educators and assist communities to better envisage how the NBN will impact the education domain.

INTRODUCTION

Amongst the most cited opinions on the likely impact of broadband on the economy are those of the distinguished US economist Raul Katz and his team at the Columbia Business School ([Katz & Suter 2009](#), [Katz 2010](#)). As a result of modelling, Katz posits that broadband's economic impact is higher 'when promotion of the technology is combined with stimulus of innovative businesses that are tied to new applications'. In these circumstances he is optimistic that the 'network effect' ([Katz 2010](#): 6) would apply to jobs creation and economic growth; however, Katz cautioned that without critical mass, broadband's economic effect would be minimal ([Katz 2010](#): 1-3).

The current struggle in Australia, which sees a nation caught in the midst of a political battle to justify ([Department of Broadband, Communications and the Digital Economy \(DBCDE\) 2011:13](#)) or decry ([Comer 2011](#); [LeMay2012](#)) the building of the National Broadband Network (NBN) is cause to reflect on Katz' observations. According to his thinking, the opportunities presented by the NBN could be squandered were Australia to have a high-speed broadband utility that lacked useful services and therefore subscribers; or, on the flip side, were Australia to have an unconvinced and therefore, under-subscribed customer base; this could cause new services to stall. Either scenario would see a diminishing of the NBN's promised returns. The aim, then, should be for wider and earlier public inclusion in the development process in order that a healthy and concurrent growth in services and subscribers occurs. But how to do this?

From the user experience design perspective, the users of currently available broadband applications are an important source of information to shape and design future NBN-enabled services ([Leonard et al 1997](#); [Norman 1998](#); [Bell et al 2011](#); [Barr 2010](#)).

In the education sector, the likely place for this to occur is within a classroom. One strategic approach is the Government initiative, the ‘NBN Enabled Education and Skills Services Program’ ([Department of Education, Employment and Workplace Relations \(DEEWR\) 2011a](#)), a \$27.1 million plan to conduct education projects ‘within or between communities to first benefit from the NBN’ ([DBDCE 2011](#)). Despite good intentions, only a small percentage of the nation can participate because the Program’s eligibility criteria limit participation to those living in designated ‘early roll-out’ zones. This pushes a large majority of potential ‘lead users’ ([Hippel 2005](#)) out of the innovation picture. Taking NSW as an example, 273 of the State’s 4,563 suburbs ([Australia Post 2012](#)) are in the early rollout scheme ([NBNCO 2012](#)); that is, 6% of the NSW population stand to benefit from the DEEWR funded program.

At risk of being overlooked are several software platforms already in use and readily available for immediate deployment. Although proprietary, they are affordable, especially as they do not require development costs. Moreover, their specifications appear to be suited to most schools’ budgets and bandwidth ([DEEWR 2011a](#)). One such platform, the online collaboration and communication tool, *Adobe Connect (AC)2012*, is being used for a number of NBN-style digital classroom activities. One of these is Zoo Connect (ZC), a science lesson developed by Taronga Zoo educators, delivered from the zoo to two secondary high schools. As an exposition of remote and blended learning using streaming rich media, ZC was runner-up in the international Adobe Exchange 2011 Education Choice Award ([Adobe 2012](#)).

This paper presents an annotated report on two evaluation trials of ZC and discusses the study’s relevance within an NBN-enabled classroom paradigm.

To begin, we contextualise ZC by discussing what a fully realised NBN classroom might be. It is important to do this so that the case study, which has some clear successes within schools’ existing broadband limits, can be considered as a useful indicator as to how classroom learning will likely evolve under the NBN, rather than, as some otherwise may be tempted to conclude, evidence that a ‘gold standard’ ([Conroy 2010](#)), FTTP service is simply not necessary.

WHAT IS AN NBN-ENABLED CLASSROOM?

Writing evocatively about NBN-enabled classrooms, Monash University’s Deputy Vice-Chancellor of Education, Adam Shoemaker, describes the NBN as removing the ‘digital rain-shadow’ that currently runs along the educational digital divide. He describes the NBN-enabled classroom as:

“.. multipoint and immersive, "many way" instead of two-way. It will make a baseline of high-quality learning available to every individual, every class - while teachers will be able to collaborate with each other across state and territory boundaries as never before.

They will be able to work across states to assess new forms of curriculum and to give them "local engagement". They will be able to develop their own pedagogical skills through peer-to-peer communities. And when students from Alligator River want to enter a science fair with young people in Deloraine, they will be able to share a "digital project" enabling Year 8 students from the Northern Territory and Tasmania to work together in a whole new way” ([Shoemaker 2012](#))

Rather more prosaic is the DBCDE’s checklist of NBN-enabled benefits to education; it includes, ‘supporting access to curriculum resources’, ‘new opportunities to extend specialist resources’, ‘educational opportunities to all Australians no matter where they live’, ‘the connectivity to develop and collaborate on innovative and flexible educational services and resources’ and ‘the opportunity for online virtual learning. ([DBCDE 2012:5](#)). DEEWR lists ‘communication’, ‘collaboration’ and ‘interaction’ as core principles ([DEEWR 2011b](#)).

Specifically, the NBN-enabled classroom will make huge demands on bandwidth due to each classroom's amassed digital activities. This could entail working with multiple digital services at the same time to crunch data, produce content and participate in online communities. There are complex privacy issues to be resolved in the classroom use of social media; but presuming these are solved, one group may be (in today's terms) uploading photos to Flickr or similar, another managing a project using Facebook. In the course of the day, students may be variously posting their music on YouTube, watching HD video, and conducting Skype-style conferences with remotely-located class colleagues and specialist teachers. They may be creating content within graphically dense and rich media virtual environments, and viewing it on mega-pixel wall screens. Schools could have the facility for tele-presence, where objects and people 'appear', projected in 3D. With all such tasks, and many others, highly symmetrical upload and download speeds will be mandatory in order to achieve quality of service.

Then, within the campus, smart objects could be exchanging data and information: sensors could monitor rainfall in the vegetable garden, a smart inventory system in the office could alert school suppliers when stocks are low, security cameras could monitor the staff car park. In addition, there may be innovation labs within the school, with classes working with open source code to configure their own niche services such as games and apps. All of these activities will need to be scaled across some 9,435 Australian schools ([Australian Bureau of Statistics \(ABS\) 2012](#)), at the same time. The pipes will need to be much wider than the present to allow for the concurrent use of multiple services. The 'big data' movement will eventually enter the learning space, further increasing the need for high bandwidth.

ZOO CONNECT

Background

The project was conceived by educators within the NSW Department of Education and Communities' Curriculum and Learning Innovation Centre (DEC CLIC) (New South Wales Department of Education and Community ([NSW DEC 2012](#))) in anticipation of digital classrooms, and the revised national curriculum implementation, both part of the Commonwealth Government's Digital Education Revolution (DER). The ZC trials took place in August 2011 and June 2012, using the readily available proprietary web conferencing and the collaboration software platform AC. Evaluation was undertaken by DEC CLIC with some of their Smart Services CRC (SSCRC) partners, including the authors of this paper. Many similar collaboration digital platforms exist ([Wikipedia 2012](#)); however the trials documented in this paper were commissioned specifically to evaluate AC, which is being used across a range of DEC CLIC purposes.

Specifically, the two ZC trials used AC to deliver a science lesson from Taronga Zoo in Sydney to Stage 4 (aged 12-14) students situated in the remote location of their secondary schools in NSW. Trial 1 took place at the co-educational Carlingford High School in August 2011. Trial 2 took place at Epping Boys High School in May 2012. In total, 111 students, three classroom teachers and three educational officers from Taronga Zoo participated.

In Figure 1, the left hand image shows Epping and Carlingford to its west, and the right hand image shows Mosman where Taronga Zoo is located, outside the NBN's early release zones, indicated by 'A' and 'C'.

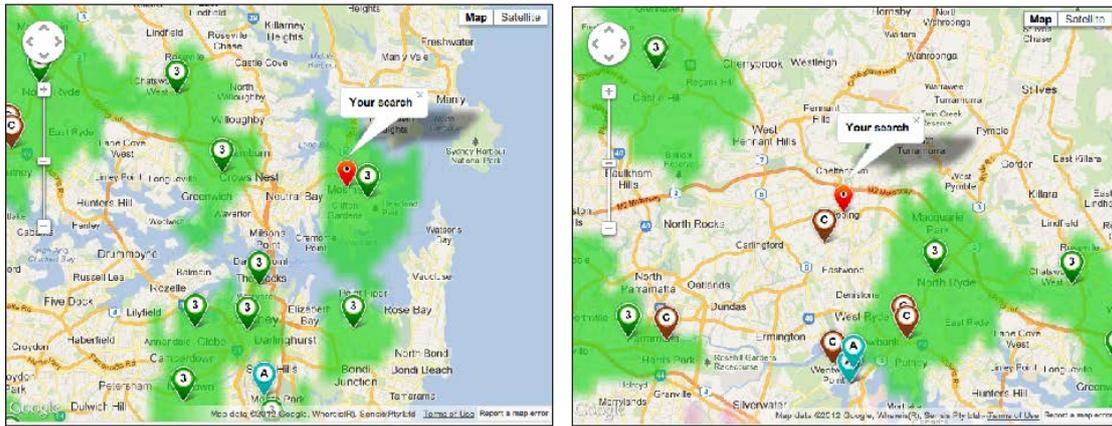


Figure 1 - At left Epping and Carlingford <<http://www.nbnco.com.au/rollout/rollout-map.html>> and at right Mosman <<http://www.nbnco.com.au/rollout/rollout-map.html>>

Aims

The primary objective of the trials was evaluation research of the AC platform to assess its efficacy and value in the secondary classroom as an e-learning environment using the DEC network. The evaluation aimed to support decision-making; was specific to AC rather than being generalised; and was designed to yield firm data on the value of AC rather than its characteristics (Gall et al 2007).

The secondary objective was exploration and investigation of usability, learning and engagement using emerging collaborative communication technologies.

Research focus

The areas to be evaluated, together with focus questions and indicators are summarised in Table 1.

Area of evaluation	Focus question	Indicators
Student outcomes	Does AC enhance student learning?	Ease of use, optimal use, levels of interaction and engagement, remote access, evaluation of pedagogy, identifying threats and obstacles
Teacher outcomes	How does AC impact on teaching practice and pedagogy?	Connectivity with students, flexibility of lesson, quality of resources developed and preparation required
	How does the use of AC in government school classrooms impact on remote participants such as experts?	Resources, costs, preparation required, outreach to students, reuse of materials, outreach to other entities
Technical and operational outcomes	Can AC be readily deployed in government school classrooms?	Resources, costs, stability of platform and set-up time, identifying threats and obstacles

Table 1 - Research focus of ZC trials

THE SOFTWARE PLATFORM

Adobe® Connect™ is an enterprise web conferencing platform for online meetings, eLearning, and webinars. An AC session is hosted and run by a nominated “administrator” who handles the collaboration tools, which are displayed as “pods” on the screen user interface. Pods include text chat, notes that can be saved and emailed, questions and answers for multiple presenters, “whiteboard”, integrated audio and video conferencing, interactive

attendee list, and survey polls/quizzes. Content can be presented in a variety of content types including animated presentations, images, audio, video, and more. It can be saved as reusable templates and stored in libraries. Files can be shared. *AC* should be capable of running on a range of platforms including Windows, Mac OS, Linux, Solaris and most Mobile platforms. A minimum bandwidth of 512Kbps is recommended for end users such as participants and meeting attendees. Wired connections of cable DSL are recommended for administrators, presenters, teachers and meeting hosts. Minimum network requirements are 100Mbps Ethernet, with 1Gbps recommended. The *AC* configuration used in the ZC trials can be seen in Figure 2.

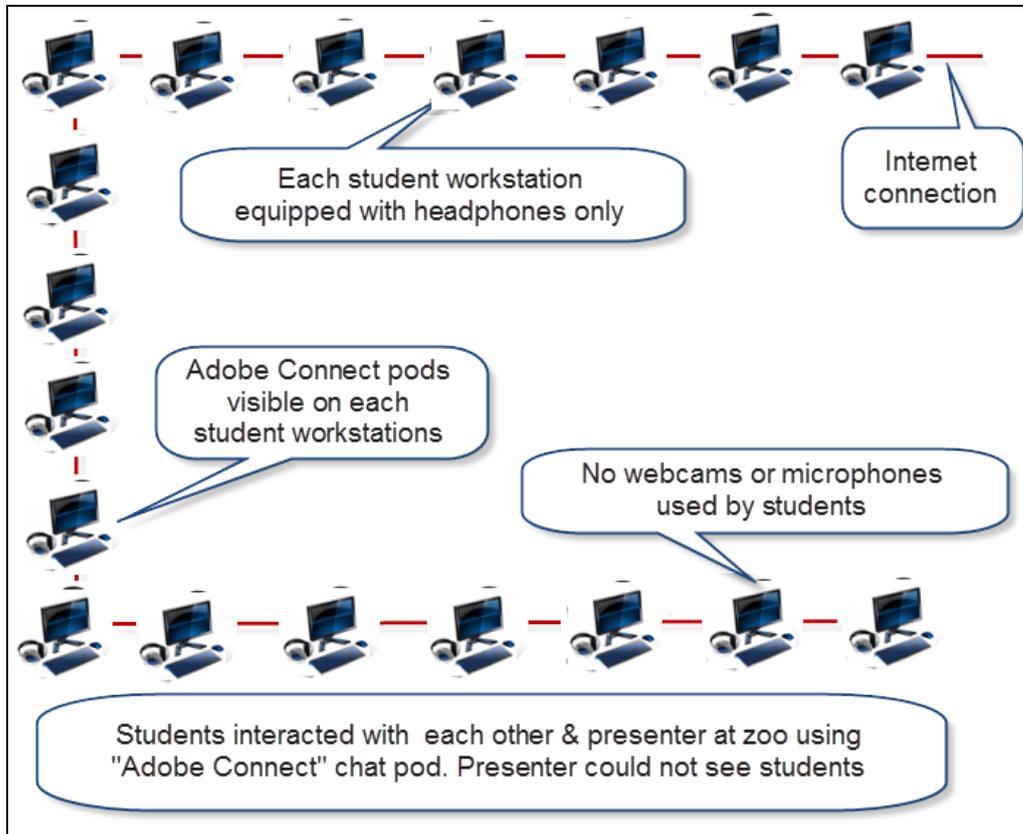


Figure 2 - Diagram design by Stephen Sergis, courtesy of DEC CLIC

NETWORK SERVICES

The AC software is hosted at CLIC and within the DEC network. Access is by invitation. Typically, the number of concurrent user groups number between 10 and 20, although Adobe claims the environment can handle up to 1000 users concurrently. *AC's* performance was assessed using current urban broadband bandwidth parameters. As at 7th August 2012, Carlingford High School and Epping Boys High School are using high capacity campus distributor servers, Figure 3.

1. **Telstra node > Epping and Carlingford Schools' DER Campus Distributer (main server) delivered via fibre optics. Bandwidth: 100 Mbps, symmetrical.**
2. **Schools' Main Server > campus blocks (buildings) delivered via fibre optics. Bandwidth: 1 Gbps, symmetrical.**
3. **Campus blocks > individual classrooms delivered via copper cable. Bandwidth: 1 Gbps, symmetrical**
4. **Connectivity mode and speeds at Taronga Zoo could not be confirmed.**

Source: NSW DEC ITD Network Solutions Team

Figure 3 - Bandwidth configuration at the test schools, Carlingford HS and Epping Boys HS.

THE ZOO CONNECT LESSON

The lesson content was taken from NSW DEC Science Syllabus Stage 4. Outcomes relevant to the lesson were:

1. Describe features of living things.
2. Classify living things according to structural features and identify that they have patterns of similarities and differences.

Present on the screen throughout most of the lesson were:

- a). the live Webcam pod of the presenting zoo teacher and
- b). the chat pod for students to ask questions.

Live audio of the presenting zoo teacher accompanied parts of the session that occupied the full screen (presentation/slideshow, quizzes and surveys). The lesson was in the following format:

- Attendance register pod where students could insert symbols to acknowledge their presence
- A video to refresh their memory of their zoo visit
- Pre-test
- Two presentation/slideshows with live narration by the zoo teachers
- Webcam of a zoo teacher with a live mammal to illustrate the lesson
- Post-test
- Experience survey

Figure 4 shows the screen at the beginning of the session. From left to right, the attendance register, the still of a video that was about to start, the chat pod and webcam of the zoo presenter.

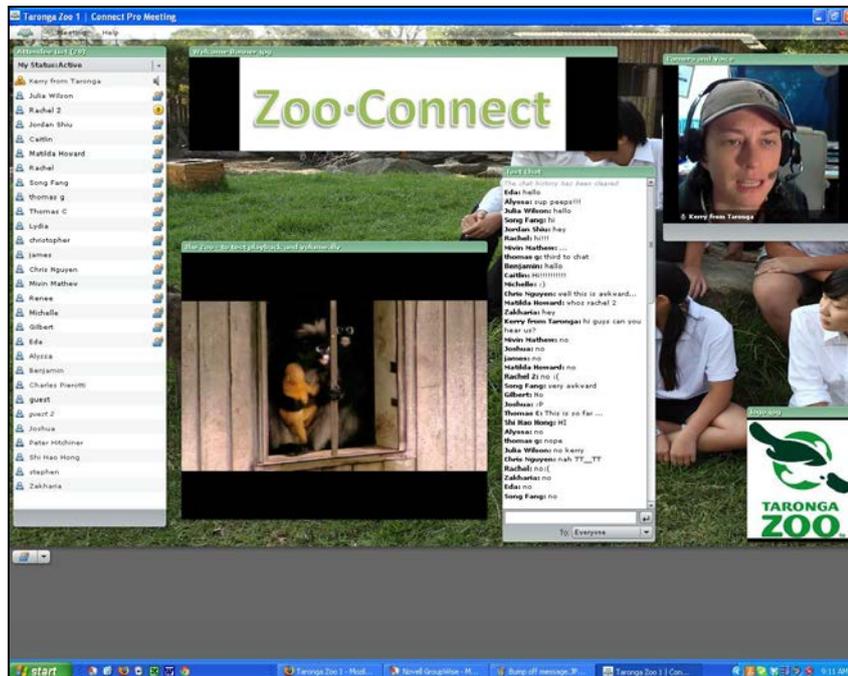


Figure 4 - ZC full screen as viewed by all participants (with browser variation)

THE RESEARCH DESIGN

The research design incorporated both qualitative and quantitative methods. In a pre-test/post-test control group design, the experimental lesson was delivered remotely by specialist teachers at Taronga Zoo using AC, whereas the control lesson was delivered by the regular science teacher in the regular classroom. Quantitative assessment of learning was supplemented by qualitative analysis of the experiences of student and teacher participants. In both groups, data from student and teacher surveys was supplemented by interviews with teachers and observation of classroom behaviour captured on video. In addition, the experimental session yielded logs of text chat entries and screen capture of the entire online lesson. Steps in the method were identical for control and experimental groups.

In summary, 111 students returned 100 complete sets of pre-tests and post-tests and 73 lesson experience surveys.

RESULTS & DISCUSSION

LEARNING

Results confirmed that ZC was extremely effective for learning. ANCOVA analysis of post-test scores adjusted for differences in pre-test scores indicated that scores of the ZC groups were higher than those of the control groups, with the Trial 1 ZC group's score significantly higher than those of the other groups ($F(3,95)=7.07, p<.0005$). In circumstances beyond the control of the experiment, the Trial 1 group was in an accelerated learning class, whereas the other groups were in regular classes. Although the significant gains made by this group could be attributed to ability, the qualitative findings support the quantitative data in suggesting that the technology was the major contributing factor.

Remote access to expertise

Survey responses and the chat transcript revealed strong agreement that students were cognisant, and extremely appreciative, of remote access to expertise and a live environment that is unavailable in the classroom. The close-up webcam images of the instructors and live animals invoked enthusiastic and empathetic responses from the students who were well aware of their privileged role as an audience. Both students and teachers commented that

exposure to live examples together with discussion driven by content experts would have enriched the potential for learning in most students.

EASE OF USE

Survey responses, interviews and observation confirmed that both students and teachers became competent in using the software within two minutes. The only aspect of ZC usability that received negative reports arose from insufficient bandwidth; 46% of responses to the question “What would most improve the lesson?” referred to blurry images, lag, and frozen sound and video. Even worse, at times teacher narration was out of step with the images they thought students were viewing, which was extremely confusing for all involved. The poor quality of streamed media could have been caused by several factors, including:

- The recommended minimum bandwidth for AC supports suboptimal quality media in some conditions
- The zoo connection, which could not be confirmed, did not comply with the minimum requirements
- The AC bandwidth preference was set too high, which would have increased both bandwidth consumption and CPU usage beyond acceptable levels, with a consequent reduction in media quality (AC 2012).

We suspect that insufficient bandwidth is the most likely of these factors because the system, including the zoo connection, was carefully configured.

Resources and reuse

The zoo teachers who prepared the lesson reported that the initial preparation was time consuming but no more so than other new lessons or technologies. Importantly, the lesson and its resources prepared for the first trial were easily reused in the second trial by both zoo and classroom teachers who had not prepared them. Furthermore, the video and presentation materials delivered by the classroom teacher offline in the Trial 2 control lesson were reported by students to be their preferred feature of the lesson.

LEVELS OF INTERACTION AND ENGAGEMENT

Statistical analysis of Likert-scale lesson experience questions and content analysis of video observation, chat pod transcript, and open-ended questions indicated extremely high levels of engagement and interaction in the ZC groups, when compared with the control groups. The teachers noted that in its use of webcams and instant messaging, AC harnessed technology currently popular with the student cohort but rarely employed in an educational context. The enthusiastic response to a delivery format with relevance to everyday life and self-concept was apparent in sustained attention, which in turn would have supported learning outcomes.

For research purposes, the teachers did not establish behavioural protocols or convey any appraisals of the platform; however students were told that every entry they posted identified them, would be stored and was easily retrievable. In these conditions, two unanticipated and striking student behaviours indicate that real-time online learning could involve new approaches to classroom management, as well as quite different learning and teaching paradigms:

Classroom behaviour

Behaviour management presented far fewer challenges in the ZC classroom than in the regular classroom. ZC participants displayed complete concentration and absorption in the lesson during both trials. They gazed at the screen intently, occasionally pausing to type, appearing particularly focused during the quizzes and surveys. The pairs of students on shared terminals appeared to collaborate politely and quietly with each other. This was in marked contrast to the moderately noisy and unruly behaviour of all Trial 2 students in the classroom and during the zoo visit when they required constant admonition. Furthermore, very little collaboration was observed at times other than the ZC session.

Student-teacher dialogue via chat pod and webcam

During the 35 minutes of each ZC session, a staggering number of entries were posted in the chat pod: 795 entries in the first trial and 1165 entries in the second trial. Textual analysis of the chat pod transcript revealed that instead of the anticipated question/answer session, students used the chat pod to express their individual identities through ‘back-chat’ commentary on the lesson, see Figure 5. In this way, a sense of community appeared rapidly and spontaneously, and students looked to their cohort rather than teachers for clarification or extension of information. Behaviour management problems arose when some students misused the chat pod with silly postings and spam (repeated entries that blocked other participants from contributing and scrolled the pod so fast that relevant postings were erased from view) preventing zoo teachers from answering questions. The accelerated learning group in Trial 1 self-regulated to rapidly eliminate the disruptive behaviour, but in Trial 2 it was necessary for the zoo teachers to temporarily hide the chat pod.

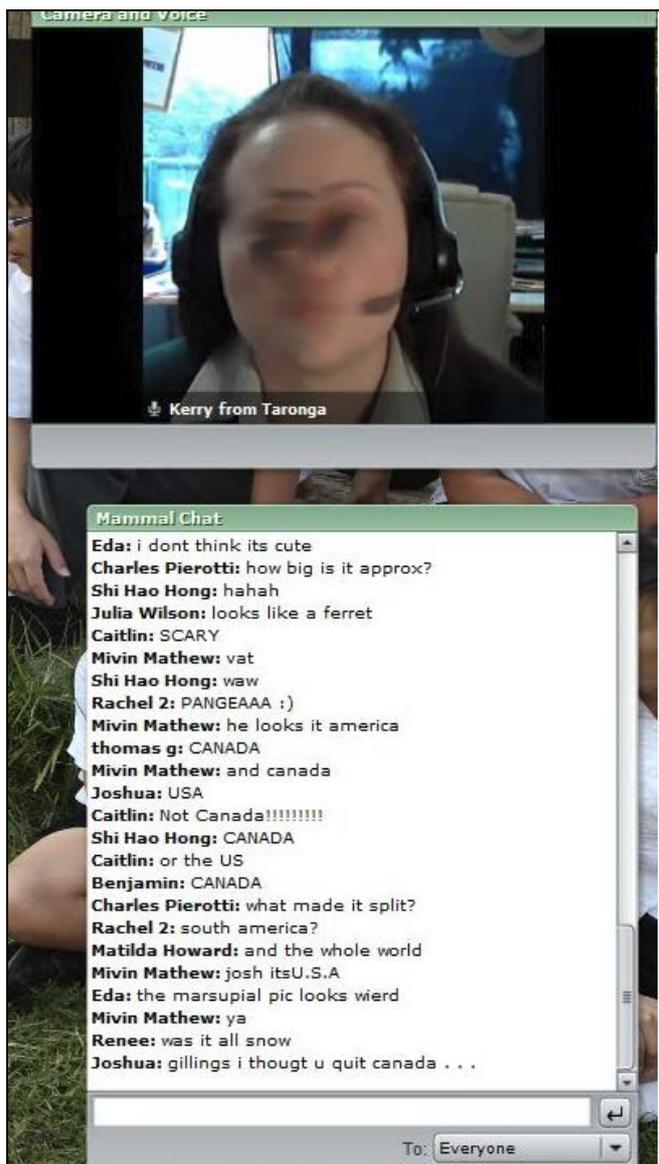


Figure 5 - Student-student clarification of information and discussion in the chat pod in Trial 1

The remote teacher perspective

The zoo teachers felt that although ‘backchat’ is a valuable means of focusing attention and building a sense of community, guidelines and protocols are needed to prevent students impeding the learning process by taking control of the discussion to ‘talk’ rather than ‘listen’, see Figure 6. They also felt strongly that a team of at least two instructors was needed so that one could present the material and communicate via webcam and the other could manage the

equipment and the chat pod. Communicating via the webcam with a class that couldn't be seen invoked a sense of 'disembodiment' or isolation in the presenters whereas the chat pod managers felt strongly engaged and developed relationships with the students they chatted to. Likewise, students appeared to develop relationships with both the delivering instructor and the chat pod manager. In common with the presenter, some suggested that two-way webcams would improve communication.



Impressions of the Sessions Chat

thomas g: AWESOME
Thomas C: This was awesome
Eda: its fun.....
james: ikr
Chris Nguyen: awesome session 8D
Jordan Shiu: awesome
Renee: great
Rachel 2: Bring more animals ???
Benjamin: ikr
Caitlin: It ROX!!!!!!!!!!!!
thomas g: better than skewl
Rachel 2: Yes
Song Fang: awesome session
Michelle: cool^^
Zakharis: it was good i liked it
Joshua: 7 outta 10
Shi Hao Hong: yep i enjoyed it definately
Lydia: a lot
Gilbert: revolutionary!
Jordan Shiu: yp
Julia Wilson: it was interactive and a fun lesson
Jordan Shiu: yep
Rachel 2: maybe bring in a orangutan :)
Rachel: it was great! "D
Alyssa: i loved this lesson. It was the best ever!
Matilda Howard: yeah, but i couldn't tpye fast enuf
Caitlin: 15 OUT OF 10
Song Fang: agreed thomas g
Eda: the animals were cute.... more live animals
Jordan Shiu: btter thanfb
Charles Pierotti: I've really enjoyed this session and hope we can do it again sometime!
Rachel 2: loved it
Mivin Mathew: it was very educative and informative! learnt new stuff
Gilbert: great work

Figure 6 - Unsolicited responses from the class as the teacher concluded the session

THREATS

While protocols and training should address the challenges presented by chat-pod behaviour management, two threats in particular could impede the deployment of platforms like ZC in schools. Firstly, poor sound and video quality due to insufficient bandwidth can distract both students and teachers, and can impede learning. A more complex, and possibly greater threat, was identified during interviews with teachers from the classroom and the zoo. Unwillingness amongst the teaching community to adopt new educational technologies, or to use them in appropriate ways, was seen as the primary threat to deployment. Only relatively new teachers were willing to participate in the trial, and more experienced teachers were recruited with difficulty, in one case passively obstructing the trial. We suspect that this resistance stems from time pressure and that teachers would be more likely to integrate the technology into their teaching practice if they were aware that their workload could actually decrease through reuse, shared resources, and delegation to experts.

CONTEXTUALISING THE ZOO CONNECT EXPERIENCE FOR AN NBN-ENABLED REMOTE LEARNING/WORKING ENVIRONMENT

The ZC experience inspired the zoo and classroom teachers to envisage many other innovative uses of online web-conferencing tools. Within the framework of the DBCDE

checklist of NBN-enabled benefits to education, the following section summarises the ZC results and some of the innovations envisaged by the teachers.

SUPPORTING ACCESS TO CURRICULUM RESOURCES

The ZC experience showed that materials developed for entire and partial lessons can be reused easily by the same or other teachers. Review of the captured lesson could assist both students and teachers. Furthermore the lesson could be set up to provide a range of experiences that senior students could tap into with a range of resources, outside the classroom context.

NEW OPPORTUNITIES TO EXTEND SPECIALIST RESOURCES

ZC exemplified the provision of specialist resources to remote locations. Other ways of extending specialist resource could be:

- Students and teachers could benefit from lessons delivered remotely by content experts in other schools. Possibly centres of excellence could be established in clusters of schools with teachers with particular expertise conducting lessons in other schools within the cluster.
- Students could connect with experts in the field who can't come to the school, for example, scientists in a laboratory, astronomers in an observatory, cabinet-makers in a workshop, or authors of books they are studying.

EDUCATIONAL OPPORTUNITIES TO ALL AUSTRALIANS NO MATTER WHERE THEY LIVE

Programs like 'Zoo Connect' can provide educational opportunities otherwise unavailable to students living in distant rural areas, or in institutions like hospitals. Regardless of location:

- Students could attend field trips and seminars that are currently unavailable to them because of distance and travel time. Instead they would need one or two periods in the classroom or laboratory.

THE CONNECTIVITY TO DEVELOP AND COLLABORATE ON INNOVATIVE AND FLEXIBLE EDUCATIONAL SERVICES AND RESOURCES

In ZC, classroom teachers collaborated with zoo experts. They suggested other collaboration activities such as:

- Group work with students presenting and recording their work, for example four break-out groups from one or more classes or different schools
- Student to student work, for example provide resources for students to present their argument in a debate from one or more classes or different schools
- Teacher collaboration and in-service training, in particular within clusters of expertise

THE OPPORTUNITY FOR ONLINE VIRTUAL LEARNING

ZC did not comply with this checkbox; however, several platforms that might comply, such as *Xbox 'Kinect'*, *Nintendo 'Wii'* and virtual world environments such as *Open Sim*, *Real Xtend* and *Second Life* are freely available. Several others, designed specifically for educational application, such as SSCRC's *iSee*, are currently in advanced stages of development.

CONCLUSION

This paper documents an extensive evaluation of an enterprise web-conferencing platform in remotely delivering a topic in the NSW secondary science curriculum. As one of a number of AC assisted lessons, the ZC program suggests that Adam Shoemaker's vision of NBN-enabled classroom has to some extent pre-dated the NBN, albeit with limitations. These obstacles notwithstanding, affordable platforms capable of supporting DEEWR's core principles of 'communication', 'collaboration', and 'interaction' are readily available for immediate deployment using existing cable DSL.

Most frustrations associated with the trial platform arose because the recommended minimum bandwidth failed to support the desired quality or functionality. The NBN roll-out should rectify these problems with improved streaming for better quality images and sound; webcams with a view of all participants, and not only teachers; and innovative technologies such as immersive environments and augmented reality, games and multiple learning modalities. These constraints aside, online collaboration platforms can still be usefully considered and ready-to-go for many schools across the nation, early roll out or not, in the transition to an internet-based curriculum.

In trialling the collaborative software platform AC in students' and teachers' own setting, (the class room and Taronga Zoo), the use case and the successes/limitations of the platform were clearly demonstrated, as was the enthusiasm of the participants for this type of learning.

The trials confirmed strong student engagement and the same or better pedagogical results, compared to traditional classroom methods, achieved with less travel. They demonstrated efficiencies of scale and teacher preparation time. They discovered that new and unexpected learning paradigms emerge when students use collaborative software familiar from their everyday lives. New behaviour management techniques and protocols are required to adjust to those new paradigms.

Importantly, a receptive teaching cohort is fundamental to deployment of programs for the NBN-enabled classroom, with resistance from time-poor teachers identified as a major threat. Teachers may need to understand that their workload could ultimately be reduced. They may need additional support in situ, with the assistance of an experienced co-teacher. They may need a reduced workload in order to make the time to learn new skills. Centres of collaboration lead by technology champions could be a good place to start.

Without the impediments of poor quality delivery, and with experience in the use and pedagogical and behavioural implication of the platform, the results would have been even stronger. It is recommended, therefore, that digital services which bring greater flexibility to learning and work environments be prioritised for development and implementation, as they provide communities with useful tools for the here-and-now, assist managers in their thinking about organisational and cultural change, and give future NBN customers a strong sense of the possibilities that lie ahead.

Finally, a word of caution: the positive findings from ZC should not be used to support arguments for an 'NBN-lite'; it would be all too easy to extrapolate from the study that as so much can be done with less, why do we need more? Yes, bandwidth to schools has been expanded to meet the increased demands of the DER's laptops-for-schools distribution scheme (Epping Boys High School for example, has over a thousand student laptops running pretty much all the time); but, as we move further into the 21st century, multiple millions of students are likely to synchronously use multiple known and yet-to-be-known digital services. Additionally, the network will be needed for distance education and home learning, with a greater prospect for students to continue accessing resources out of school hour. This will far outstrip capacity gains made under the recent DER upgrade. The more constructive approach to schools' latest improvement in bandwidth capacity is to opportunistically experiment, as DEC CLIC have done, developing lead users, student mentors and public advocates for a new style of learning along the way.

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