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Addressing the Falling Interest in School Science in Rural and Remote Areas Using Experiments and Science Fairs

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Abstract: This paper reports on outcomes from the ‘CYScience’ project which was developed and used in North Queensland, Australia. This mainly ‘hands-on’ approach includes teacher professional development, a Science Fair and a CYScience experiment kit, consisting of many of the components required for the completion of the experiments outlined in the manual. There is also a website where information about the project and resources such as videos can be accessed. The prime motivation for development of the project was to contribute to addressing the problem of falling levels of interest in studying science in the state and nation’s student group, particularly in rural areas with an emphasis on Indigenous students. The founding proposition was that hands-on, inquiry-based science would boost student interest in science in ways that a didactic style of pedagogy failed to do. This paper outlines the evidence that interest in science has declined in Australia. It also examines the ongoing debate about the respective merits of inquiry versus didactic pedagogical approaches in terms of content development, understanding scientific processes, appreciation of science and preparation for effective citizenship whereby citizens are well-prepared to understand and participate in important public debates around issues such as climate change. Results will be presented from a mixed-method study that included data from the CYScience website evaluation survey; CYScience Fair and kit evaluation taken directly after delivery; telephone interviews approximately 12 months after the Science Fair, continuing use of the CYScience kit, as well as an in-depth interview with the CYScience facilitator. The paper concludes by examining the results and drawing conclusions concerning the effectiveness of the CYScience program.

Key words: Hands on science · Experiments · Science education · Science fair

INTRODUCTION

Australia’s chief scientist, Ian Chubb, recently commissioned a report entitled ‘The Status and Quality of Year 11 and 12 Science in Australian Schools’ conducted by Goodrum, Druhan and Abbs [1] of the Australian Academy of Science. When launching the report, Chubb, Australia’s Chief Scientist, commented that students had abandoned science in staggering numbers, pointing out that 20 years ago, 90% of Year 12 students studied some form of science whereas the current participation stood at a greatly reduced 50%. Chubb argued that the scientific literacy of the community was becoming increasingly important and that “the community has got to be in a position where they are better able to make judgments, rather than be led by the loudest and most vociferous”. Chubb, in his opening address to the National Science Communications Conference in Sydney, pointed out that “between 1992 (after which school retention rates were fairly stable) and 2009, the proportion of Year 12 students taking physics, chemistry and biology fell by 31%, 23% and 32% respectively. The proportion taking one of advanced mathematics or intermediate mathematics has dropped from 41% to 29% over the same period”. Goodrum et al.’s report stated that “One of the surprising results is the dramatic fall in the collective number of students studying science” [1]. Earlier in 2009, Tytler highlighted the “concern with declining interest in science over the Years 7-10” [2], which was the catalyst for the Victorian government to invest in the largest school science initiative that had been undertaken in Australia for decades and it followed hundreds of
Victorian primary and secondary schools over a three year period. At the international level, Jenkins [3] wrote about the “anxiety over the decline in interest among students, especially in the developed world, in the physical sciences as subjects of advanced study” [3].

A recent study by the authors tracked 9 years of special funding from the federal government to support education in rural areas through the PCAP grant scheme in North Queensland. This analysis revealed that science ranked 5th out of 22 curriculum areas in terms of how communities decided to spend these additional funds. This underscores the importance of science in the minds of rural communities. CYScience was developed on the premise that science education in North Queensland schools was sometimes characterised by an overuse of direct teaching approaches and that this stifled student interest. In particular, current approaches were especially inappropriate for Indigenous students. Goodrum et al.’s report provided evidence that direct teaching approaches were dominating science instruction in Australian schools. They pointed out that “the content-laden curriculum encourages science in Year 11 and 12 to be taught in a traditional way using the transmission model. This approach is revealed by the fact that 73% of science students indicated that they spend every lesson copying notes from the teacher while 65% never or seldom have choice in pursuing areas of interest. Teacher demonstrations are common, with 79% of science students suggesting this occurs often, very often or always in a lesson.”[1]. This however, does not necessarily demonstrate a causal relationship between an over-emphasis on direct teaching and falling student interest but it does indicate that current approaches were not working in relation to fostering student interest in science.

It is reasonable to assume that didactic teaching approaches in combination with the ‘hands-on’ approach that underpins CY Science and regular testing would lead to students gaining better content knowledge and appreciation of scientific approaches. However, this assumption has been challenged by some studies. For example, Pine et al.’s [4] study of 1000 fifth graders in the US found no significant differences in content knowledge or scientific investigation skills in the text-based versus inquiry groups. To test content knowledge, the researchers used Trends in International Mathematics and Science Study (TIMSS) items and they found no significant difference between the two groups. The researchers sensibly concluded that the quality of delivery using either method varied considerably in the participating classroom sites. Pine et al.’s study indicated that hands-on approaches can produce at least equivalent outcomes in terms of content knowledge and may have an advantage in terms of increasing student interest.

Schauble, Glaser, Duschl, Schulze and John [5] caution that poor delivery of inquiry based programs can also be perceived by students as being boring, irrelevant and incoherent. It was apparent in sites participating in their study that quite a few of the ‘hands-on’ activities were like exercises that exhibited an emphasis on drill and mastery and involved the practice of what they termed ‘disembodied skills’ where students struggled to see the relevance or how the ‘exercises’ related to their lives. Schauble and colleagues expressed disappointment in regard to the students’ acquisition of scientific content or understanding of scientific processes after completing a full year engaged in an intensive hands-on science program. They concluded that students learn best when they are involved in real investigation rather than working through a set of unrelated activities. This finding is supported by Ornstein’s [6] study where increasing the relevance of the hands on activities led to an increased level of student interest. Ornstein also concluded that “more challenging, open ended experimentation and inquiry experiences produced more positive student results” [6]. Students in Finland also endorsed the importance of relevance by requesting more out-of-school connections with science activities, less teacher presentations of content and reading from textbooks and more discussion of difficult concepts [7].

Hart, Mulhall, Berry, Loughran, & Gunstone[8] argued that their study supported the view that laboratory work gave students valuable insights into how scientific knowledge is established. The Roberts Report [2002; cited in 9] in the United Kingdom argued that practical science work played a vital role in the development of the appreciation of scientific inquiry, although after reviewing the report and undertaking a study, Abrahams and Millar [9] reported that an appreciation of scientific and understanding of conceptual knowledge needs a balanced approach where practical work is scaffolded by class discussion and traditional pedagogy. Other researchers, [e.g. 10, 11, 12] also recommend a balanced approach where well integrated and relevant student inquiry is followed up with teacher directed discussion and guidance. Bergman argued that “in the consolidation segments, for example, it is unlikely that students will spontaneously discuss concepts without guidance. It is even more doubtful that most students will be able to arrive at correct understandings without the teacher’s assistance” [11].
Tytler [2] refreshingly, does not debate the relative merits of inquiry versus didactic approaches when leading the implementation and study of the largest recent science intervention in Australian schools, but instead outlined eight principles of effective science teaching: “encouraging active engagement with ideas and evidence; challenging students to develop meaningful understandings; linking science with students’ lives and interests; catering for individual student learning needs; embedding assessment within the science learning strategy; representing the nature of science in its different aspects; linking science with the broader community; exploiting learning technologies for their learning potential.” In order to implement these eight principles, teachers would need to adopt a balanced approach to science pedagogy and ensure that students had access to engagement in relevant, practical activities such as those afforded by CYScience. These principles apply regardless of whether the approach is hands-on or didactic and would contribute to the success of either approach, although the authors favour a combined approach.

A critical enabler of hands-on science to occur more frequently in Australian schools is changing the perception of teachers who often view practical science as too challenging a task to undertake. They may also hold other negative perceptions about hands-on science, such as believing that it does not contribute to the development of content knowledge and this would be a particularly powerful inhibitor in the current educational environment where performance in tests is given the highest priority. Another impediment is centred on teacher’s beliefs that appropriate resources, including internet resources, are not available or too time consuming to put together without laboratory or other assistance. The following section of the paper reports on a study to determine teacher’s perceptions of the CYScience resources, including the website resources and teacher’s perceptions of the science fair and science activities supported by the kit to generate teacher and student interest in science and to provide a positive learning experience for students.

**Cyscience Program:** The CYScience Professional Development (PD) session was presented to teachers in 13 North Queensland state schools in 2010 and 2011. The PD was undertaken by 152 teacher aides, student teachers, teachers and principals. Additionally, 415 students were involved in the CYScience Fair and 78 CYScience kits were provided to the 13 schools. The CYScience project was funded by DEEWR (Department of Education, Employment and Workplace Relations) through the Far North Queensland Indigenous Schooling and Support Unit (ISSU), which is part of Education Queensland, the State Education Authority. This project used the ‘Link and Learn’ model that links educators to relevant PD activities developed to improve education and employment outcomes for Aboriginal and Torres Strait Islander people across the state.

**MATERIALS AND METHODS**

A mixed method approach was used to evaluate the CYScience project, which was comprised of multiple data collection phases involving forced-response quantitative survey data and qualitative data obtained from open-ended and interview questions. Determining results utilizing multiple methods is more robust and valid than relying on a single method research design [13, 14]. Furthermore, methodological triangulation was used, which is particularly desirable when seeking a comprehensive understanding of real world situations [15-17]. Evaluation was carried out in four phases:

- CYScience website evaluation survey
- CYScience Fair evaluation survey taken directly after PD delivery
- CYScience telephone interviews approximately 12 months after the PD delivery
- CYScience Fair PD facilitator interview

**RESULTS**

**CYScience Website:** The CYScience website was designed to provide teachers with a website that complimented the CYScience kits. The CYScience website was designed to provide flexible PD delivery and be easy to navigate and was comprised of video clips of students engaged in science experiments. Sixteen pre-service teachers at JCU were invited to evaluate the CYScience website content, authority, organization and presentation, accessibility, comparability and emotional response to the CYScience website. A website questionnaire was administered to the group of pre-service teachers who had studied website evaluation. The questionnaire was comprised of 13 forced-response questions using a five-point Likert scale (1 = Strongly Disagree; 2 = Disagree, 3 = Neither Agree or Disagree; 4 = Agree; 5 = Strongly Agree).
Results of CY Science Website Evaluation: The results indicate that the pre-service teachers evaluated the CYScience website favourably. Figure 1 provides the responses to the questions, “The CYScience website......”

The results from the 13 question forced-response survey, which asked the participants to evaluate the CYScience website on a 5-point Likert scale, indicated that the pre-service teachers rated the website very highly; between 4 (agree) to 5 (strongly agree). The three questions that were rated the highest (4.8 on a 5-point scale) found the website “easy to contact organization [CYScience] if necessary” (Question 4), “easy to navigate” (Question 5) and “motivates to obtain or use the materials” (Question 13).

The CYScience website evaluation survey also included an open-ended question, “What could be done to improve this website?” Participant responses included:

- Promote the manual more in website beyond having to download pdf file.
- Home page button at bottom of pages to navigate back.
- Feedback posted from students as well as teachers as they are the reason for this science initiative.
- Like the pictures on the pages, however, I think when going to each page I would rather see the content more than the graphics when I enter that particular page.

CYScience Fair PD: In 2010 and 2011 the CYScience Fairs were conducted in 13 North Queensland Schools. A facilitator provided 78 CYScience kits and PD to 62 Prep to Year 11 pre-service teachers and teachers (Figure 2).

The CYScience Fair was presented to 415 students enrolled in Years four, five, six and seven. The students were engaged in completing 4 activities in chemical science: fake snow, balloon inflation, making slime and slime circles. The students were provided with a CYScience booklet containing step-by-step instructions for each of the experiments with questions to answer (Figure 3). While the students in each year level completed variations of the same activities, the content questions, prediction and communication of experiment results and curriculum links were tailored to each year level, becoming increasingly more complex.

At the completion of the PD activities, the pre-service teachers and teachers were invited to complete an evaluation of the CYScience Fair PD. The questionnaire was comprised of 13 forced-response statements using a five-point Likert scale (1 = Strongly Disagree; 2 = Disagree, 3 = Neither Agree or Disagree; 4 = Agree; 5 = Strongly Agree). All of the participants agreed or strongly agreed that they and their students enjoyed the CYScience Fair (Figure 3).

All of the teachers agreed or strongly agreed that the Science Fair was enjoyable for them and that the Science Fair was enjoyable for students.

The CYScience Fair PD was overwhelmingly perceived as a positive learning experience for students and all of the student teachers and teachers agreed or strongly agreed that they were inspired to use the CYScience kit (Figure 4).

All of the participants agreed that the experiments were well presented and the website was perceived as a helpful in assisting with experiments by 94% of the participants, with 6% of teachers indicating a neutral response (Figure 5). Note that 10 pre-service teachers responded that this statement was not applicable to them.

An area that received mixed opinions was the response to the statement: “There was sufficient amount of time allocated to cover the content and the experiments in the CYScience Fair” (Figure 6).

Figure 7 indicates that there was a general consensus that the experiments were easy to perform and that the experiments will be interesting and exciting for the students.

Finally, the pre-service teachers and teachers were asked if the exposure to the CYScience Fair changed the teachers’ or the students’ attitude towards science and maths. While the majority (63%) of the participants strongly agreed or agreed that the CYScience Fair PD had changed their attitude towards science and maths, just over one third of the pre-service teachers and teachers were neutral or disagreed with this statement. However, the majority of those who disagreed wrote that they had always been interested in science and maths. For example, two of the participants who provided a neutral response to this statement noted, “I already loved science.” A similar trend was seen from the participants’ opinion on whether the CYScience Fair PD changed students’ attitude towards science and maths with 60% strongly agreeing or agreeing (Figure 8).

The surveys provided space for the participants to include comments about the CYScience Fair that were not captured in the forced-response items. Some participant comments provided specific suggestions for improvement. For example, four participants commented about measurement issues:
Fig. 1: Pre-service teacher’s responses to 13 questions evaluating the CYScience website

Fig. 2: The year levels of teachers involved – including pre-service teachers.

Fig. 3: Responses by teachers and students to the CYScience Fair

Fig. 4: Pre-service teachers’ and teachers’ attitude towards the CYScience learning experience.

Fig. 5: Pre-service teachers’ and teachers’ attitude towards the CYScience website to assist with experiments.

Fig. 6: Pre-service teachers’ and teachers’ attitude towards the CYScience PD learning experience.

Fig. 7: Pre-service teachers’ and teachers’ attitude towards the CYScience on-line Science Manual and their responses to the statements: “The experiments were well presented” and “The experiments were easy to perform” and “The experiments will be interesting and exciting for the students”.

- The instructions need to be a bit clearer as to what is being used for measuring. (Female, Year 5 teacher)
- The instructions could be in smaller steps. The switching from ‘measure’ to mls and back again was confusing. (Female, Years 2/3/4 teacher)
Fig. 8: Responses related to teachers’ and students’ attitudes

- Make explicit the measurement amounts, plus write in more instructions for slime making. (Female, Year 6/7 teacher)
- Need more measuring gear. (Female, Year 5/6 teacher) Other, more general, comments included:
- I would love the materials a day or so before the experiment. (Female, Year 7)
- We required extra time as we allowed for student discussion. Workbooks could be a little larger to help assist children with reading or learning disabilities. (Female, Year 5 teacher)
- A great morning. However, would like to do the experiments on separate occasions to really gain as much as possible from the students. (Male, Year 6 teacher)
- Student’s enjoyed session. Only downfall was that they all couldn’t help at once.
- I enjoyed and my science teaching confidence is growing. (Female, Year 4 teacher)

**Final Comments from Participants Included:**

- This fitted perfectly with our science unit on materials and current topic of fair tests.
- This is a real bonus because normally we do not have access to this equipment. (Female, Year 6/7 teacher)
- Great ideas! The students were really excited and didn’t realize they were learning. (Male, Year 5 teacher)
- Students were all actively engaged and many made statements, such as “Science is cool” and “I like science”. (Female, Year 4/5 teacher)

**Cy Science Pd Telephone Interviews:** Fifty-one (82%) of pre-service teachers and teachers who participated in the CYScience Fair PD provided their email addresses for follow-up evaluations of the program. These teachers were contacted by email and invited to participate in a semi-structured telephone interview, each to take about 15 to 30 minutes of the teacher’s time. Over an eight month period in 2011, 204 emails were sent to the teachers who provided their email address (one email in Term 2, two emails in Term 3 and one email in Term 4). Twelve teachers responded by email that they were too busy with other school commitments to participate in telephone interviews and other teachers did not reply to the emails, in addition, quite a few emails bounced due to small server space allowances for teachers’ email resulting in full email inboxes.

Ultimately, 11 teachers (22%) agreed to participate in the telephone interviews evaluating the CYScience PD (nine female teachers, two male teachers) from eight schools (representing 62% of the participating schools), agreed to take part in the telephone interview. The telephone interviews were semi-structured and consisted of six questions. The variation in interview time was determined by the teachers as they were encouraged to reflect on the value of this PD activity and some teachers chose to elaborate on their PD experience. The telephone interviews were digitally recorded and transcribed.

**Results of the CYScience Fair PD:** Results of the CYScience Fair PD program revealed that the program was successful for both teachers and students. One female teacher stated, “it would be wonderful if the CYScience PD could be taught again this year as it was so motivating to me and gave me a lot more confidence in teaching science.” Table 1 below provides the interview questions and examples of the teachers’ responses.

The phone interviews were semi-structured, therefore additional information was volunteered by the participants, which provided additional insights into the teacher’s experience of the CYScience PD program. These comments fell primarily into three themes:

- Linking science to other subjects;
- Time constraints making it difficult to have time to engage in science experiments or science fairs; and
- Networking with other teachers in rural and remote Queensland.

**Linking Science to Other Subjects:** One teacher provided a good example of how the ‘snow experiment’ was conducted in her class and how she linked science with literacy,
### Table 1: Telephone interview questions and sample responses from the teachers who participated in the CYScience PD.

<table>
<thead>
<tr>
<th>Question</th>
<th>Quotations from Teachers</th>
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<tr>
<td>1. How has the CYScience kit impacted on the science you have taught? The</td>
<td>The quality of Science that can be taught requires teachers who are confident in teaching science. Hands-on experiments are always interesting but I know I am reluctant to do experiments, especially those that use specialized equipment, beakers, or ingredient we don’t have. It can be a bit intimidating. (Female, Year 4/5 teacher) I’ve had numerous conversations with teachers who I followed up with at a later date who confirm more use and their schools have ordered more kits. We have also followed up on the use via Skype. They have professional development after school and then they take that kit into their classroom and they run the fair with their students. (Female, Year 6/7 teacher) The kit engaged teachers and student in scientific inquiry and it helped them to see science is not as daunting as they thought. The kit inspired and provided teachers with confidence to have a go. (Female, Year 5 teacher)</td>
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<td>amount of science? The quality of science?</td>
<td></td>
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<td>2. From what you have seen in the class, what effect has the CYScience</td>
<td>I have never seen my class so rapt…and rapt for so long. It was fantastic. They really loved it. (Female, Year 4/5 teacher) It showed the kids how easy it is to make fun experiments. They all came back the next day talking about having shown everyone at home what they’ve been doing in school. (Male, Year 5 teacher) The students seemed to be more excited and actively asked questions and were trying to investigate further. Students have easy to follow experiments having both pictures and short concise steps. (Female, Year 7 teacher)</td>
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<td>Kit experiments had on the students?</td>
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<td>3. The science kit comes with a manual with a series of experiments. Have</td>
<td>The website was probably better than the manual as it showed you step by step how to do the experiments. (Female, Year 4 teacher) The reason it [CYScience] is so effective is because they [the teachers] have the box of materials and that they also have the manual and the instructions are explicit. (Male, Year 6 teacher) We have used the manual and followed all the investigations pretty much concisely. Most teachers in their classrooms have done the same because it’s so simple to follow and everything is in there and ready to go. (Female, Year 4 teacher)</td>
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<tr>
<td>you used the manual and followed the investigations or have you made</td>
<td></td>
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<td>modifications along the way?</td>
<td></td>
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<td>4. How has the Science kit affected the perception of teachers and students</td>
<td>I never really liked to teach Science and I’d try and palm it off to someone else because doing experiments always made me feel nervous. However, these experiments were really, really easy to do and I gained a lot of confidence. (Female, Year 4 teacher) All of the teachers spoke about how easy it was to do the experiments. None of us made mistakes. (Male, Year 5 teacher) The kit has pushed myself and others to explain concepts within science using a hands-on approach. It also pushed many of us to make sure that there’s a strong link between English and Maths so that students can be exposed to scientific concepts as well as other concepts within the curriculum. (Female, Year 6 teacher)</td>
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<td>towards science education?</td>
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<td>5. What was the reaction of Indigenous students in your class to the</td>
<td>The indigenous students probably were more likely to take the experiments home to show their family. So, that engages the family in the experiences their child is have at school, which probably results in motivating the parents to encouraging their child to go to school. (Male, Year 6 teacher) One Indigenous boy hated pen and paper work. So, he sat there with his slime in a ziplock bag and he played with the slime for ages. (Female, Year 4 teacher) I think what they [Indigenous students] appreciated was how hands-on the activities were and I run a modified approach with those classes as you have smaller classes and we have adapted the CYScience Fair to make it more hands-on. (Female, Year 7 teacher) One of the problems we have is even getting the Indigenous students to come to school. However, when they knew we were doing experiments we had no Indigenous absences…not just in my class, but in all of the classes that were doing experiments, which we thought was terrific. They loved it. They were more involved in school and more motivated to come to school. (Female, Year 6/7 teacher)</td>
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<td>experiments from the Science kit?</td>
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<td>6. Did you notice any emotional response from the students during the</td>
<td>The kids all loved it….all of them wanted to try more and more experiments. They were very motivated. (Female, Year 4 teacher) I think it made an impression on the students that every day counts, that school can be fun and that they could share what they learned at school. (Female, Year 6/7 teacher) We didn’t have the typical behavioural problems when we did the experiments. The students were focused, engaged, motivated and having fun. (Male, Year 5 teacher)</td>
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<tr>
<td>CYScience Fair or when using the kit? If yes, please elaborate on the</td>
<td></td>
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<td>emotional response.</td>
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A good example is the making of the snow, for instance we started off that experiment by looking at a disposable nappy, so we pulled a disposable nappy apart and we identified the snow inside that nappy. We then did a fair test with two different types of nappies where we added water to two types of nappies until they reached saturation point so even though the nappy started to drip out the bottom or the nappy split open at the top and we could decide which one had the most snow in it as that was the most absorbent nappy. We relate what we did to prior experiments, we talked about the process and we talked about the vocab and the properties of the materials, how the properties changed…. What we do is linked to science and literacy in these sessions. (Female, Year 4 teacher)

Another teacher reported that she made a deliberate connection between the CYScience experiments with maths. She stated that,

- **From the science perspective with CYScience, there’s a lot of scope to embed more science in it. From a maths perspective, because it’s difficult to engage students with maths, I can see the benefits of using science to engage students.**
- **Initially it would be worthwhile to engage the students totally with science and then to build on that with the maths.** (Female, Year 6/7 teacher)

A third teacher reported that she was planning on linking science experiments with technology, responding that,

- **There is a possibility of this type of science being spread across to other disciplines, like technology. We are having a big technology project in Term 4 and maybe we can add some experiments.** (Female, Year 4/5 teacher)

**Time Constraints:** Several teachers also pointed out the difficulty in have time to run CYScience experiments because of an already full curriculum and the added time pressures with the National Assessment Program - Literacy and Numeracy (NAPLAN). For example,

- **The introduction of NAPLANhas put enormous pressure on teachers to prepare their students for testing, therefore, it has had a very negative effect on teaching time in the classroom. There is little, if any, time available for other programs, such as CYScience.** (Male, Year 6 teacher)
- **It would be good to have more time for CYScience but when we are done teaching all that we are required to teach there is never enough time to work in experiments.**
- **Right now in science we are studying insects so the experiments don’t suit that area of science. Hopefully we can use it more in Term 4 because it’s a pity to have the equipment but no time to use it.** (Female, Year 4/5 teacher)
- **The students ask to do more experiments, however, we just don’t have sufficient time to do all the things we need to do and work in some experiments. It’s really a shame because the students are so engaged and motivated when doing experiments.** (Female, Year 5 teacher)

**Networking with Other Teachers:** The schools that participated in the CYScience PD program were regional, rural and remote schools in North Queensland, therefore networking with other teachers was considered by many of the teachers as being extremely beneficial. However, a recurrent theme regarding insufficient bandwidth and a variety of complaints associated with insufficient bandwidth, frustrated teachers and impeded networking between teachers and schools. Examples of the teacher’s frustration were,

- **There are obviously problems of insufficient bandwidth that negatively impacts on communication/networking between teachers and schools…. The problem is that teachers’ time is already stretched and wasting time trying to get connected, or stay connected, is an added pressure.** (Female, Year 4/5 teacher)
- **Slow internet connections and drop-outs are frustrating to students and teachers.**
- **Sometimes we spend the time we planned to do an ICT lesson and instead we are showing students how difficult it is to use computers at school. We all find it frustrating and this is a poor lesson for students who feel that they have to use their home computers to accomplish the lesson. Then I have the problem that some students don’t have a home computer, so, to be fair, we just don’t do the task.**
- **Providing fast, reliable connections for schools is imperative.** (Male, Year 5 teacher).
We [teachers] are working harder and longer than 10 years ago. Fast, reliable computer networks could facilitate coping with all of the added work we are expected to complete. And, we have a lot more computers in the classroom, however, this is not a computer issue but instead is a bandwidth issue, whereby school connections are slow and unreliable. (Female, Year 7 teacher)

Why have a computer for every student when our schools have such poor connection speeds and frequent drop outs? What’s the point? (Female, Year 3/4 teacher)

Eventually, however, the roll out of the NBN across Australia should facilitate better networking experiences in the future. Despite bandwidth frustrations, several teachers reported that Skype was very useful in facilitating networking between teachers and schools, for example,

- It certainly helps having a Skype session when they’ve had a hands-on experiment prior to the PD or them doing a science fair. (Female, Year 4 teacher)
- Skype is really useful and a superb method of networking, especially for hands-on content, such as the science experiments. We can show each other how we would demonstrate the experiment. Sometimes Skype drops out, which can be a bit frustrating, however, we just reconnect and continue on. I don’t think that Skype dropping out has hampered the networking as it's easy to reconnect and continue with the demonstration. (Female, Year 6 teacher)
- It's hard to get good PD for teachers in remote schools. So, having Skype allows us to participate in PD activities and when we get a disconnect we just re-connect.
- That generally works for me. (Female, Year 6/7 teacher)

**CY Science Fair Facilitator Evaluation:** The CYScience Fair PD facilitator participated in a face to face interview. The aim of this interview was to obtain additional information about how the program could be improved.

The semi-structured interview was comprised of seven questions. The interview was digitally recorded and transcribed. Each question is followed by the facilitator’s statements.

Do you think that the CYScience materials provided in the kit will lead to more teachers using hands on science?

- Yes, I believe it does as I’ve had numerous conversations with teachers who I followed up at a later date who confirm more use and their schools have ordered more kits... Teachers have professional development after school and then they take the kit into their classroom and they run the fair with their students. The reason it is so effective is because they have the box of materials and they also have the manual with explicit instructions.

The facilitator confirmed that she was discussing the ‘PD in a Box’ initiative. The facilitator was then asked, if the program received good participation through the Skype sessions.

- Yes, most teachers and teacher aides participated, even those who weren’t currently teaching in the classroom so weren’t necessarily going to follow up the activities with students. They were curious and enthusiastic about the science fair. The PD was also a social event for staff in remote locations.

As many of the schools are in rural or remote areas of Queensland, the facilitator was asked if she had any issues with Skype working satisfactorily in those areas. The facilitator explained that,

- There were times that it cut out but we reconnected and sometimes it was an issue and I think that until they have better broadband access in those places it will continue to be an issue but having said that, we did manage it and I guess that we became used to it occasionally dropping out and we just reconnected and continued the session.

With the NBN being rolled out, the facilitator was asked if she thought that this would improve delivery of the program. The facilitator responded,

- Yes and I see it not only for science but more generally for teachers in remote areas. It will be hugely beneficial to have that accessible to them.

As this program was designed to promote interest and learning for Aboriginal and Torres Strait Islander people, the facilitator was asked how the activities were received by Indigenous students in particular. Similar to the comments of some of the teachers who were also asked specifically about the learning impact the CYScience had on Indigenous students, the facilitator replied,
The Indigenous students receive the activities enthusiastically because it is so hands-on and there’s a lot of oral language. Other strategies besides repetition and the emphasis on oral language, is the explicit nature of the concept definitions and the inclusion of real life applications the students can relate to..... For the younger students, the fake snow activity links to their essential learning in regard to natural and processed materials which requires them to understand the properties of a material and why it is chosen for a particular purpose. As Indigenous students find abstract thinking challenging, this activity is of particular value as it demonstrates concepts without requiring this.

The facilitator was asked to talk about the deliberate connection of CYScience with Maths. The facilitator responded that,

- Initially the activities engage the students in science and then build on that by requiring them use maths processes to collect, record and analyse data. It’s a clever way to embed maths without students realising it is ‘maths’ that they are doing.

Next, the facilitator was asked to think about what the next step could be in furthering the CYScience project. The facilitator provided several initiatives that could be implemented,

- It’s got so much potential. One initiative is to teach the activities utilising the ‘5Es Teaching and Learning’ model in the fair. We can cover the first three (Engage, Explore and Explain) phases in a condensed manner. Then I’d like to see science being made more explicit in the manual. We could start by linking it to the National Science Curriculum because that’s the next development and will provide legitimacy for the project in the future. The nine experiments include a strong maths component but we could develop another set of experiments concentrating solely on science, which is more in-line with curriculum requirements at this point in time. As science is taught in units (a series of lessons including an investigation) in schools, we need to develop some units that are supported by the materials in the kit. This increases the use of the kits.

Finally, the facilitator was asked if there were any difficulties with implementation of the CYScience project. The facilitator provided three areas that could improve the implementation of the CYScience PD program:

- Sufficient measurement equipment would enhance the CYScience Kit.

- A significant challenge has been measuring equipment. In talking to teachers, the lack of measuring equipment has made things difficult. There is potential to have some measuring equipment in the kit without adding too much bulk. For instance, the kit comes in a box and we might be able to find a bucket that fits neatly within that box and then put the resources inside.

- There needs to be a strategy to encourage teachers to continue to use the CYScience kit and the website, a reminder of its value.

- Another significant challenge is whether the teachers will use the kit again. I think there are a fair percentage of kits that will sit in the storeroom after the visit and not be used again. This is why I think it is important that the project continues so that teachers are reminded. Skype can help remind the teachers and keep them engaged and we are also developing small video clips for the website. Given how easy it is now to make your own videos on all sorts of mobile devices, there’s potential for the future, so that if people come up with a new idea or new experiment that can also be uploaded on the CYScience website so that this is a very dynamic website that people are adding to and giving feedback on other people’s experiments therefore making use of Web 2.0 technologies.

Summary of Findings: Overall the CYScience website and the Science Fair PD program were very well received by both teachers and the students. The program was
particularly successful in engaging Indigenous students who were captivated by the hands-on approach to learning used in the Science Fairs. A brief summary of each of the four evaluation strategies is presented next which will demonstrate how using a mixed method research design and methodological triangulation is able to confirm the results; thus providing an in-depth evaluation of the CYScience program.

**CY Science Website Summary:** The CYScience website was evaluated by 16 pre-service teachers from JCU. The results were very positive with the teachers indicating that the website was easy to use, that they felt confident that they could contact the CYScience team through the website if needed and that the website motivated teachers to use the materials. The opened-ended question, which asked the participants to provide areas where the website could be improved, provided some practical suggestions that would be easy to add to the CYScience website, such as to promote the manual more and having a home page button at the bottom of each page to assist users in navigating back through the website.

**CY Science Fair Professional Development Summary:** The CYScience Fair was evaluated by 62 pre-service teachers who were trained in website evaluation (n = 27) and teachers (n = 35) in 13 North Queensland schools. There was overwhelming support for the CYScience Fair PD experience with the results indicating that 98% of teachers enjoyed participating in the PD activity and the teachers felt that 94% of students enjoyed the CYScience Fair. Additionally, the teachers strongly agreed that the Science fair was a good learning experience for their students and they felt inspired to use the CY Science kits.

All of the teachers (100%) agreed or strongly agreed that the experiments were well presented, however, only 74% of the teachers agreed or strongly agreed that they would use the CYScience website to assist with experiments in the future and 6% of the teachers were unsure. This lower than expected evaluation was clarified by the open-ended comment section of the survey where many of the pre-service teachers stated that had difficulty answering this question. One could easily speculate that pre-service teachers may not have enough classroom experience to determine what type of assistance they might require in the classroom.

There were mixed results when teachers responded to the statement that there was “sufficient amount of time allocated to cover the content of the experiments in the CYScience Fair”. Seventy-seven percent of the teachers agreed or strongly agreed that there was sufficient time, however, 20% of teachers were neutral or disagreed that there was sufficient time to cover the experiments. This is an area that might be addressed in future PD. Most of the teachers (90%) agreed or strongly agreed that the experiments were easy to perform and 94% agreed or strongly agreed that the experiments would be interesting to their students.

Finally, only 63% of the teachers reported that they agreed or strongly agreed that the CYScience Fair PD changed the teachers’ attitude toward science and math. Again the opportunity to provide comments on the survey verified that the wording of the question was problematic as many of the teachers stated that they already loved science and math so their attitude towards science and math did not change. This is a good example of triangulation of data to explain this lower than expected result. Also the comments section of the survey provided some valuable feedback on how the CYScience PD could be improved, such as by having more measurement tools provided in the kits so that the teachers didn’t need to provide these, that extra time for each experiment would allow for more consolidation of the information and that a workbook could be larger to assist students with reading or learning difficulties.

**Telephone Interview Summary:** In some cases the telephone interviews were conducted approximately 12 months after the CYScience Fair PD was delivered and in other cases it was soon after the delivery of the program. These interviews provided a great deal of insight into the teachers’ and students’ experience of the CYScience Fairs. The main findings were:

- The hands-on experience improved teacher confidence in conducting experiments in their classrooms and more CYScience kits had been ordered.
- The teachers reported that their students were very engaged in CYScience Fair and the students have been asking the teachers if they could do more experiments.
- Some teachers preferred using the CYScience Manual where others preferred using the website, which indicates that sufficient instructional resources were provided.
- The teachers reported that the hands-on experiments particularly engaged Indigenous students and also improved their classroom behaviour and attendance.
The teachers stated that their students were motivated to do more science experiments and that the students were excited and having fun learning. The teachers had no problem in linking science to other subjects and the teachers reported that they were actively trying to make even more linkages so that the CYScience kits could be used more frequently.

The telephone interviews revealed that time constraints (e.g. NAPLAN) made it difficult for teachers to integrate the CYScience experiments into the everyday classroom and teachers mentioned that they were unhappy to see the CYScience kits sitting unused on a shelf for the majority of the time. Additionally, bandwidth problems made networking with teachers in other schools frustrating. However, on a positive note, the teachers found that using Skype to network was working and when it dropped out they just reconnected and continued.

**CY Science Facilitator Interview:** The CYScience Facilitator interview confirmed much of the results that had been collected in the previous evaluation phases of the CYScience Fair PD. The facilitator specifically addressed how receptive the Indigenous students were to hands-on-learning and reported that the students often did not realize that they were using the math that was embedded in the experiments. She also mentioned that it would be beneficial to develop more experiments that would link to the national science curriculum.

Three areas that the facilitator felt would improve the CYScience PD would be to provide all of the measurement equipment in the kit so that teachers have all of the materials they need in the kit. Second, she suggested that there needs to be a strategy to encourage teachers to use CYScience kits more frequently and link science and maths to other subjects, as well as strategies for networking with other teachers and/or schools. For example, the facilitator suggested that students make videos of the experiments that they conduct and upload the videos to the CYScience website to share with other schools. Finally, the facilitator recognized that organizing science fairs requires time. She suggested that teachers and/or schools might benefit from assistance in organizing science fairs.

**Methodological Triangulation:** The qualitative data collected from the open-ended question and comment space that was offered to the participants provided an explanation of the findings that may have been misleading if relying on the quantitative data alone, particularly in explaining the data from the CYScience Fair PD. Therefore, the mixed-method research design and methodological triangulation has increased the validity of the results by providing corroboration and explanation of the findings by the use of a four phase evaluation of the CYScience PD program.

**IMPLICATIONS AND CONCLUSION:**

Despite the potential of practical hands-on science to increase student interest and fill an important role in a balanced approach to school science programs, it continues to be regarded by teachers as a challenging task [12]. This study provides strong evidence that the CYScience project, involving a science fair and hands-on experiments, supported by a materials kit and a website, can lead to improved teacher perceptions about practical science activities in terms of providing a positive learning experience and increasing the interest and enjoyment in science for teachers and students. Teachers overwhelmingly reported that this framework for supporting student engagement with practical, hands-on activities did lead to increased student and teacher interest and enjoyment in relation to science. In order to create a balanced approach in schools between hands-on and didactic approaches, teachers need to have the motivation to implement approaches that are often considered to be messy and time consuming in their preparation phase. The CYScience approach was regarded by teachers as a way to alleviate these problems and the effects of the program lasted well after the science fairs were conducted and the first use of the science kit. The interviews taken up to a year after the initial events confirmed sustained effects in the medium term. Further studies would need to be conducted to determine longer term effects. While the approach was successful in enabling a more participative approach by students [18], further work is needed to tie the activities to the new National Australian Curriculum and ensure that the design of the activities take into account Tytler’s[2] eight principles of effective science instruction.

**REFERENCES**


