Presented to the National research in Science Education Research (NARST), New Orleans, LA, 22 April 2007

INDUSTRY-FUNDED, CONTENT-RICH PROFESSIONAL DEVELOPMENT: INFLUENCES ON ATTITUDES TOWARDS APPLIED SCIENCE

Dianne Nichols, Education Queensland, Australia
Dan Churach, Centre for Sustainable Resource Processing, Perth, Western Australia
Darrell Fisher, Curtin University of Technology, Perth, Western Australia

This paper reports on a novel project aimed at having a positive impact on the "people shortage" within the minerals and energy sector in Australia. In response to a downturn of students enrolling in the "enabling sciences" (chemistry, physics and mathematics), a government funded research centre, a university science department and several industry partners collaborated in a teacher professional development program. The aim was to highlight the value of applied science in contributing to the nation's wealth as well as to showcase a variety of high tech, science-rich career opportunities for school students. The literature review supports the notion that teachers have a high degree of influence on the career choices their students make. Using the collaborative resources of academic, research and industrial partners, teachers involved in the program had multiple opportunities for gaining hands-on laboratory experiences in the chemistry and physics of mineral processing. The professional development offerings also afford a variety of tours to research facilities and organised site visits to mines and processing plants of industry partners. Quantitative and qualitative evaluation of the effectiveness of this pilot program at impacting on teacher attitudes towards the industry is reported.

Objectives of the Study

This research investigates the most appropriate professional development model for the delivery of information about science and industry to science teachers to ensure a positive change in student learning. Using government and industry funding, science teachers participated in a range of professional development events targeting different mining and mineral processing industries that exposed teachers to the high-tech nature and career possibilities of those industries for their students. The study traces the interaction of teachers involved in content-rich professional development events based around the mining and mineral processing industries. In particular, the research determined teacher change in the following areas: increased content knowledge and pedagogical practice, attitudes towards the mining and mineral processing industries and ability to form networks with scientists in industry and with other science teachers. The project is on-going and this paper reports on findings to date.

Significance of the Study

At a time when fewer students choose to study physical sciences at the secondary level, the Australian mining and mineral processing industries have an increasing demand for bright, qualified young people seeking research and leadership careers with in the industry. The need for improving science education has been identified, and governments throughout Australia are making commitments to ensure students have access to high quality science education. This includes exposing students to complex, real-world problems in both industry

and research institutions (Spotlight on Science, 2003). The government and industry funded professional development events provided for science teachers allows teachers to provide for their students a realistic view of the mining and mineral processing industries.

The Australian mining and minerals processing industries have expanded at an increasing rate over the last few years and this trend is expected to continue due to the growing demand from China and India for Australian raw materials. Simultaneously the supply of young science graduates gaining the academic credentials and in science, technology, engineering and mathematics needed to maintain a qualified workforce continues to dwindle. This problem has been well documented, but no easy solution has become apparent (Nicol & Woffenden, 2002, Bartier, Tuckwell & Way, 2003, Churach, 2004a).

One Australian Cooperative Research Centre (CRC), the Centre for Sustainable Resource Processing (CSRP), wanted to raise community awareness of the mining and mineral processing industries. Operating under the assumption that there can be no research without researchers (or no employer without employees), the CSRP sought a method to involve the minerals processing and energy industry with the community at large. Anecdotal feedback from school science teachers in Western Australia indicated that few teachers had an insight to the high-tech nature of the research undertaken by the mineral resource sector. The question arose as to the most effective method of reaching the community and in particular, young people who may be interested in the mining and mineral processing industries as a career choice.

The answer to this question can be answered in terms of where young people receive their inputs and who they turn to when they are looking for information. The Western Australian Government's Youth Survey (2003) surveyed 7,919 young people aged 12-25 years across all socio-economic backgrounds and educational circumstances. The study showed that teachers are held in high regard and that they have influence over their lives (third in rank behind parents and friends). Teachers are well positioned to positively influence their students' attitudes towards science and encourage them to consider careers in science and industry (Churach, 2006).

In a sense, these findings support the old notion that "the best salesperson is word of mouth". Why does word of mouth carry such weight? Simply put, most people place a stronger value of influence on input from those whom they know best and with whom they have a longstanding relationship. That parents and friends rank 1 and 2 as the most influential on opinions is easily predictable. In the same sense one can understand the high ranking of teachers as opinion influences. For the most part, young people spend their "working days" in the company of teachers and in many cases, interact with some teachers for more hours per week than they would normally interact with a parent. If all things are be equal, the target audience to be reached would be parents and friends though in terms of numbers, there is little leverage to be gained in attempting to reach (for example) 20,000 parents in order tin influence 30,000 of their children. We can say with great confidence that the teacher-student relationship is real and that these relationships already exit.

Theoretical Underpinnings

There is a need for science teachers to confidently teach applied science and its links to industry. Science that is taught by making these links increases the relevance for teachers and their students and makes the learning experience authentic. However, teachers cannot engage their students if they do not have the correct industry knowledge themselves. As science teachers have the opportunity to attend "real world" professional development events,

including industrial laboratory work and field trips that are aimed at increasing their knowledge of industry practices this will allow teachers to build their confidence.

Science education in Australia has experienced major changes in recent years. Outcome-based syllabuses have been implemented to give students opportunities to demonstrate their learnings with an emphasis on "Working Scientifically". This is to give students opportunities to learn to work the way real scientists work by investigating, understanding and communicating in real life contexts (Queensland School Curriculum Council, 1999). West Australian implemented a similar syllabus at about the same time (Curriculum Council of Western Australia, 1998). The new syllabuses provide a vehicle for teachers to include industry practices, along with the associated science, into their curriculum.

Professional development was offered to teachers at various support levels throughout Australia to enable them to teach the new syllabuses. Some schools were able to access grant funding to plan and organise professional development events (Quality Teacher Program, 2003). Because the new syllabuses were based on the constructivist approach to teaching science, much of the professional development was focussed on this constructivist approach. However, to successfully implement the new syllabuses, teachers needed to increase their pedagogical content knowledge (PCK). PCK was proposed by Shulman (1987) as one component of an effective teacher's professional knowledge. When sustained, long term professional development is provided, it gives teachers the freedom to choose areas that align with their perceived needs. Consequently, teachers will gain confidence to use this in their teaching practice (Harrison & Nichols, 2002).

The concept of teaching authentic industry applications in their science classes may be new to some teachers and they may require specific content knowledge and access to information about industry practices. Teachers may feel the need to make industry visits and establish links with scientists to gain content knowledge to confidently teach it. They may not be aware of the opportunities available to them and may not have the time to find out. To enable teachers to affect students' perceptions about industry, teachers need to be exposed to a variety of hands-on experiences and industry visits (Churach, 2004b).

According to Hoban (1997), this approach is an "outside-in" model, where knowledge (in this case, industrial science and skills) is generated by others for the teachers. However, the CSRP program encourages teachers to reflect upon their newfound knowledge. New content knowledge helps teachers to identify ways to translate their learnings into the classroom and improves their teaching practice (Loucks-Horsley et al., 1998). Adey (2004) has modelled factors that influence the effectiveness of professional development programs for teachers and has shown that a number of factors must be set in a positive condition to be effective and to cause a change in student learning.

During the past few years the CSRP and Murdoch University (Western Australia) have collaborated with a range of industries to offer an array of educational activities for secondary science teachers, initially in Western Australia and more recently in Queensland. The project places the emphasis on the on-going nature of the program and is based on the idea that in order to have long term effects on student perception of the industry, participating teachers need to undergo a variety of experiences involved with resource processing. Ideally, teachers would gain the greatest benefit from being exposed to a variety of both academic experiences (e.g., hands-on laboratory work and lecture-type offerings) and industrial experiences (e.g., plant and mine tours as well as work experiences) on an on-going basis rather than one-time only events. This would allow the teachers involved to develop relationships with scientists and industrialists to a point where they feel comfortable in asking questions and sharing experiences (Churach, 2004b).

Over a period of time it would seem natural for teachers to gradually integrate their newfound knowledge into the curriculum and to have positive impacts on their students' perceptions of the mining and mineral processing industries. A similar Canadian project indicated increased positive outcomes when career options became infused into the curriculum and not taught as separate items and recommended professional development to be provided for teachers to accommodate this approach (Millar, 1995).

Research Questions

The research questions that guide the design of this study are:

- Has the professional development event increased the teachers' content knowledge?
- Has the professional development event positively impacted on the teachers' pedagogical practice?
- Can the teachers make links between the professional development event and the science curriculum?
- Are teachers viewing the mining and mineral processing industries in a positive light?
- Are teachers forming networks with scientists working in industry and also networking with other science teachers?

Design and Procedure

For the pilot study reported on here, science teachers participated in professional development events provided by CSRP in partnership with Murdoch University. The events included:

- short courses and workshops ("The chemistry and physics of extractive metallurgy", Advanced extractive metallurgy", "Online interactive learning: Providing a minerals industry context for secondary learning", Geology and mineralogy in the resource sector",
- research facility and industry tours (atomic force microscopy, CSIRO Minerals Research Centre tour, gold mine tour, bauxite mine tour, alumina processing tour,
- a variety of resource processing public lectures, and
- mini sessions for science teachers focusing on the mining and mineral processing industries.

The number of teachers participating in these professional development events was some 225 teachers over the past 4 years in Western Australia and an additional 40 in Queensland. The number of teachers participating in the professional development events varied depending on the activity and some teachers participated in more than one event. In some cases individual teachers took part in five or more events. Teachers were encouraged to remain networked via email with other participating teachers and with the scientists conducting the event.

A survey called an "Attitude Inventory", developed by Churach (2005) and reviewed by academic staff at Murdoch University Extractive Metallurgy and the Science and Mathematics Education Centre at Curtin University of Technology, has been used to determine attitudinal change after teachers had been involved in a professional development event. In this pilot study 44 Western Australian teachers were asked to fill a survey after the professional development event/s in which they participated.

Respondents answered numerically on a 5-point Likert Scale with 1 being "Strongly Disagree" and 5 being "Strongly Agree". Participants were asked to respond to each of the

16 items from their point of view before their first professional development and then again from the point of view after undergoing whatever number of professional development events they completed within the program.

The 16 statements on the survey were:

1. My overall knowledge of the mining and mineral resource industry is very extensive.
2. I believe that careers in the mining and mineral resource industry are worthwhile recommending to my students.
3. I have a very positive attitude towards the mining and mineral resource industry in Australia.
4. I believe an excellent way to solve environmental problems can be found through mining and mineral resource research.
5. I use examples of the mining and mineral resource industry in my classes frequently.
6. I know a scientist I can email or phone to get information concerning a mineral processing or chemistry question.
7. I consider mining and mineral resource industries in Australia to be modern and high-tech.
8. I think that mining and mineral resource industries offer exciting career paths for young people.
9. I talk to colleagues and friends about issues concerning the mining and mineral resource industry in Australia.
10. I believe that people in the mining and mineral resource industry care about the natural environment.
11. The more teachers do hands-on activities, the better they will understand the mining and mineral resource industry.
12. I provide information to students concerning the possibility of a mining and mineral resource major at university.
13. I have a positive view of career researchers and scientists in the mining and mineral resource industry.
14. Getting a bit on and “inside view” of the mining and mineral resource industry makes me a better teacher.
15. Getting a bit of an “inside view” of any Australian industry makes me a better teacher.
16. PDs that offer a maximum amount of science content-oriented material make me a better classroom teacher.

The results of all the surveys were tallied to find the average response for each question both before and after the respondents participated in the professional development events. Though actual values of responses can not be taken as a meaningful reflection on the professional development program, the shift in average response can be interpreted as a change in teacher attitude towards mining and mineral processing industries. A positive shift in score is interpreted as a positive shift in teacher attitude towards the industry while a negative shift in score is viewed as a negative shift in teacher attitude towards the industry. A two tailed t-Test for paired samples was run on each of the 16 statement sets in the survey.

Findings

The pilot data has been tabulated (Table 1) to show the average shift in attitude for the sample of teachers before and after the professional development events. Each of the 16

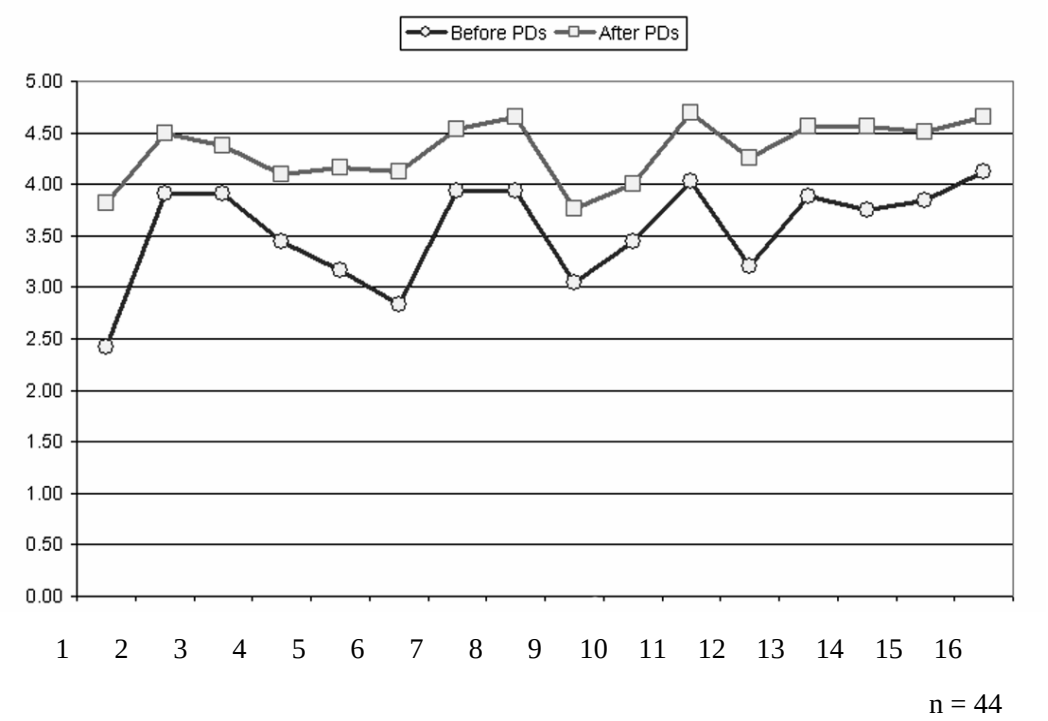
Table 1: Pilot study results on shift in teacher attitudes before and after PD events.

Item	Before PDs	Today	Shift	Item	Before PDs	Today	Shift
Knowledge	2.43	3.81	1.38	Talk to Friends	3.02	3.76	0.74
Recommend Career	3.88	4.48	0.60	Cares Environment	3.43	4.00	0.57
View of Industry	3.88	4.36	0.48	Hands-On Helps	4.00	4.69	0.69
Help Environment	3.43	4.10	0.67	Recommend Uni Major	3.17	4.24	1.07
Use Class Examples	3.14	4.17	1.02	View Researchers	3.86	4.55	0.69
Know Scientist	2.86	4.12	1.26	M & MR PD Good	3.71	4.55	0.83
High-Tech Industry	3.90	4.52	0.62	Any Industry PD Good	3.81	4.50	0.69
Offers Exciting Career	3.90	4.64	0.74	Content PDs Good	4.10	4.64	0.55

topics the change was found to be statistically significant ($p<0.01$). This can be interpreted as indicating that the changes in attitudes shown by teachers were much more likely to have been associated with the professional development events they had attended rather than any kind of chance occurrence.

When this pilot data is graphed (Figure 1) in this way the shift it is easy to see the nature of a positive shift. Each topic had a positive shift but to different extent. The two greatest shifts in response where the teachers' overall knowledge of the mining and mineral processing industry (Likert shift = 1.38) and teachers getting to know and networking with scientists (1.26). Other notable shifts in teacher attitudes were in teacher willingness to provide career information to students (1.07) and to use mining and mineral processing examples in class (1.02). Standard deviations are also listed for each scale indicating the spread of responses. In the four attitude shifts mentioned here, small standard deviations implies that participants

Figure 1:
Graphical representation of mean response before and after teachers participated in PDs.



showed similarly large changes in responses, which would be anticipated if a strong association exited between teacher professional development events and attitude changes.

Conclusion and Recommendations

This pilot study assesses the impact of content-rich professional development events on science teachers' attitudes towards the mining and mineral processing industry. The data collected using the "Attitude Inventory" has shown a positive change in attitude across all topics covered in the survey to varying extents. The data from this survey could be enhanced by interviewing a sample of teachers to determine the reasons for their change in attitude.

The research is ongoing and the number of teachers surveyed will grow as more teachers access the professional development events both in Western Australia as well as Queensland. Teachers who participate in the summer teacher program conducted by the Colorado Mining Association and Colorado School of Mines will also be included in the sample during the northern hemisphere summer of 2007.

The survey also indicates that teachers are prepared to contact scientists to obtain information about their work. Email lists have supported this and also indicate that teachers are emailing each other for information about the mining and mineral processing industry. Additional data will be collected as tteachers are asked to give descriptive written answers about their attitudes to the professional development events and to determine how the event has influenced their planning, teaching and assessing. Information about teachers making links between the professional development event and the science curriculum cannot be determined from the survey data alone. A segment of the sample will be interviewed in order to collect teachers' curriculum documents and assess the long term success of the program.

References

Adey, P., (2004), *The Professional Development of Teachers: Theory and Practice,* Kluwer Academic Publishers, London.

Bartier, F., Tuckwell, K. & Way, A., (2003). *Supply of professional staff: Is there a problem?* AusIMM Bulletin: Journal of the Australian Institute of Mining and Metallurgy. Jan/Feb 2003 p30-34.

Churach, D., (2004a). *Bridging the gap: Science teachers hold the key to our future.* AusIMM Bulletin: Journal of the Australian Institute of Mining and Metallurgy. Jan/Feb 2004 p28-32.

Churach, D., (2004b), Teacher-Industry Synergies: A convergence of problems offers sustainable solutions, *The Journal of the Science Teachers' Association of Western Australia*, vol 40, 2 pp.

Churach, D., (2005), Teacher professional development as the key to a sustainable workforce in the mineral resource sector, presented at the *Fourth International Conference on Science, Mathematics and Technology Education*, Victoria, Canada.

Churach, D., (2006). *Teacher professional development as the key to a sustainable workforce in the mineral resource sector.* Fisher, D., Zandvliet, D., Gaynor, I. & Koul, R. (Eds), Sustainable communities and sustainable environments: Proceedings of the Fourth International Conference on Science, Mathematics Education. Curtin University, Perth.

Curriculum Council of Western Australia (1998). The Curriculum Framework. Perth, Western Australia.

Harrison, A., & Nichols, D., (2002), *Enhancing science teachers' pedagogical content knowledge at Biloela State High School*, Science Works for the Smart State Conference, State of Queensland, Department of Education.

Hoban, G., (1997), *Opportunities for Knowledge Building in Professional Development Models in Exploring Professional Development in Education,* Social Science Press, Wentworth Falls Australia.

Loucks-Horsley, S., Hewson, P., Love, N., & Stiles, K., (1998), *Designing Professional Development for Teachers of Science and Mathematics,* Corwin Press, California.

Millar, G. (1995). *Helping Schools with Career Infusion.* ERIC Clearinghouse on Counseling and Student Services, Greensboro NC, Canadian Guidance and Counselling Foundation Ottawa (Ontario).

Nicol, M., & Woffenden, M., (2002). *The future of extractive metallurgy*, Presentation at Parker Centre Industrial Advisory Committee. Murdoch University, Perth.

Quality Teacher Program, (2003), *Celebrations: Stories of Success*, Queensland Government, Brisbane.

Queensland School Curriculum Council (1999), *Science Years 1 to 10 Syllabus*, Publishing Services, Education Queensland, Brisbane.

Shulman, L., (1987), *Knowledge and teaching: Foundations of the new reform*. Harvard Educational Review, 57, 1 22.

Spotlight on Science (2003). *Science State, Smart State*. Queensland Government, Brisbane.

Western Australian Government Youth Survey. (2003), accessed on line at http://www.youthsurvey.wa.gov.au/

Witkowsky, D. (2004). How do we promote mining? Educate teachers ─ they educate students. *Mining Engineering* (October 2004).

Appendix 1: Teacher Attitude Inventory

Murdoch University Extractive Metallurgy / Centre for Sustainable Resource Processing Teacher Professional Development Program Feedback Survey

We are gathering data in an attempt to measure the effectiveness of the GAMSET / CSRP / Murdoch University Teacher Professional Development activities. Please take a few minutes to complete the following series of questions concerning your attitudes towards the Mining and Mineral Resource industry and how these attitudes may have changed after your participation in our Teacher Professional Development Program.

You are asked to respond to each of the following statements twice, firstly from the perspective you had before the Mineral Processing Professional Development work you have done and secondly from your perspective today after having participated in one or more of these events.

Your feedback will help to make our professional development work more supportive of you and other teachers in the future. Be assured that this study follows all guidelines concerning privacy and the information you provide will be kept confidential.

Thank you in advance for your input. You can follow the on-going report of our research at the Centre for Sustainable Resource Processing website at http://www.csrp.com.au/.

Regards,
- Ms Di Nichols, PhD Candidate, Curtin University of Technology, SMEC, Perth, WA, Australia, dnich25@eq.edu.au
- Dr Dan Churach, Education Manager, CSRP, Bentley, WA, Australia, dan.churach@csrp.com.au

Name _____ School _____
(optional)

How many Murdoch University / CSRP Professional Development activities have you participated in to date? Tick the boxes that apply.

Intro PD ☐ Advanced PD ☐ On Line Learning PD ☐ Laboratory Tour ☐
Industry Tour ☐ STAWA Future Science ☐ Community Lecture ☐
Any Other Activity sponsored by CSRP/Murdoch? _____

		Strongly Disagree	Disagree	No Opinion	Agree	Strongly Agree
My overall knowledge of the Mining and Mineral Resource industry is very extensive?	1. Before the first PD	1	2	3	4	5
	2. Today	1	2	3	4	5
I believe that careers in the Mining and Mineral Resource industry are worthwhile recommending to my students.	3. Before the first PD	1	2	3	4	5
	4. Today	1	2	3	4	5
I have a very positive attitude towards the Mining and Mineral Resource industry in Australia.	5. Before the first PD	1	2	3	4	5
	6. Today	1	2	3	4	5
I believe an excellent way to solve environmental problems can be found through Mining and Mineral Resource research.	7. Before the first PD	1	2	3	4	5
	8. Today	1	2	3	4	5
I use examples of the Mining and Mineral Resource industry in my classes frequently.	9. Before the first PD	1	2	3	4	5
	10. In the future	1	2	3	4	5
I know a scientist I can e-mail or phone to get information concerning a mineral processing or chemistry question.	11. Before the first PD	1	2	3	4	5
	12. Today	1	2	3	4	5

Thank you in advance for your input. You can follow the on-going report of our research at the Centre for Sustainable Resource Processing website at http://www.csrp.com.au/.		Strongly Disagree	Disagree	No Opinion	Agree	Strongly Agree
I consider a Mining and Mineral Resource in Australia to be a modern, high-tech industry.	13. Before the first PD	1	2	3	4	5
	14. Today	1	2	3	4	5
I think that a Mining and Mineral Resource industry offers an exciting career path for young people.	15. Before the first PD	1	2	3	4	5
	16. Today	1	2	3	4	5
I talk to colleagues and friends about issues concerning the Mining and Mineral Resource industry in Australia.	17. Before the first PD	1	2	3	4	5
	18. Today	1	2	3	4	5
I believed that people in the Mining and Mineral Resource industry care about the natural environment.	19. Before the first PD	1	2	3	4	5
	20. Today	1	2	3	4	5
The more teachers do hands-on activities, the better they will understand the Mining and Mineral Resource industry.	21. Before the first PD	1	2	3	4	5
	22. Today	1	2	3	4	5
I provide information to students concerning the possibility of a Mining and Mineral Resource major at university.	23. Before the first PD	1	2	3	4	5
	24. In the future	1	2	3	4	5
I have a positive view of career researchers and scientists in Mining and Mineral Resource industry.	25. Before the first PD	1	2	3	4	5
	26. Today	1	2	3	4	5
Getting a bit of an “inside view” of the Mining and Mineral Resource industry makes me a better teacher.	27. Before the first PD	1	2	3	4	5
	28. Today	1	2	3	4	5
Getting a bit of an “inside view” of any Australian industry makes me a better teacher.	29. Before the first PD	1	2	3	4	5
	30. Today	1	2	3	4	5
PDs that offer a maximum amount of science content-oriented material make me a better classroom teacher.	31. Before the first PD	1	2	3	4	5
	32. Today	1	2	3	4	5

THANK YOU FOR YOUR PARTICIPATION