Teacher professional development as the key to a sustainable workforce in the mineral resource sector

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Abstract

At the same time the world is experiencing a China-led boom in metal demand, the mineral resource industry in Australia and much of the rest of the western world is faced with a shortage of professional staff, an ageing workforce and falling numbers of young people choosing careers in the mineral resource sector. Even more, the dwindling supply of students studying the "feeder sciences" to the mineral processing industry (eg., chemistry, chemical engineering, physics, geology) has caused a steeper downturn in the supply of university graduates willing and able to pursue Higher Degrees by Research (HDR) within this economically vital sector. The paper reports on a novel project run jointly by the Centre for Sustainable Resource Processing, Murdoch University Department of Extractive Metallurgy and the Parker Cooperative Research Centre for Integrated Hydrometallurgy Solutions. This program aims to have a positive impact on this people shortage by positively affecting the attitudes of secondary science teachers by providing a range of professional activities for them. 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 have 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 organises site visits to mines and processing plants of industry partners. Evaluation of the effectiveness of this pilot program is reported.

Overview

The problem: Who will create tomorrow's wealth?

When one thinks about the multitude of products we use at the most basic level, everything that human beings consume is at some stage mined, pumped or grown. In Australia the mining and mineral resource sector is by far the largest wealth-creating industry for the country. Nearly a third of Australia's export income is dependent upon this industry. Specifically, during the 2003-2004 financial year the income from the overseas sale of metallic minerals and metals totalled $AU32.3 billion and that represented 27.5% of all the money Australian earned through merchandise exports (Australian Commodities, 2005). More, the Australian mineral resource sector has expanded at an increasing rate over the last several years, mostly due to the growing demand for raw materials from China. Simultaneously the supply of young science graduates gaining the academic credentials and experiences in the Science, Technology, Engineering and Mathematics (STEM) needed to maintain a qualified workforce continues to dwindle. The problem has well documented, but no easy solution has become apparent (Nicol & Woffenden 2002, Bartier, Tuckwell & Way, 2003, Churach, 2003).

The issue has been viewed with particular concern for the education programs of two Australian Cooperative Research Centres (CRCs) conducting research in the mineral resource sector in Australia. Operating under the assumption that there can be no research without researchers (or no employer without employees) the AJ Parker CRC for Hydrometallurgy and the Centre for Sustainable resource Processing, have searched for a way to involve the mining, minerals and resource processing industry with the community at large. The question arises as to the most effective method of reaching "the masses", as it were. One might be tempted to reach young people through the media, but the question remains as to how to target this audience in an efficient, cost effective manner.

How does one "speak" to young people?

The answer to this question must be answered in terms of where young people receive their inputs and who they turn to when looking for information. The Western Australian Government's *2003 Youth Survey* shows that by far, the single most tapped source of information for young Australians today (at least in

WA) is the Internet. Even more, the reliance on the net for information has doubled (37% in 2000 to 75% in 2003) in just the past few years.

Certainly television, radio and newspaper advertisements could have some impact on success in reaching the audience in question, but at what cost? As an example, in September 2002 the Parker Centre placed advertisements publicising postgraduate scholarships in the weekend metro Perth newspaper at the cost of several thousand dollars and received no meaningful response from any interested students. Moreover the sources of information that young people tap are not the same as the influences that affect life choices (e.g., how they chose a career pathway).

Who do young people listen to?

It is again informative to look at WA *2003 Youth Survey*. This work queried a sizable sample of 7,919 young people (aged 12-25 years old) across all socio-economic backgrounds and educational

Table 1:
Source of Information by Age, 2003.

To get information, young people use…	12-14 years old			15-19 years old			20-25 years old		
	Often	Some-times	Never	Often	Some-times	Never	Often	Some-times	Never
Internet / on-line	76%	19%	5%	78%	19%	3%	71%	23%	6%
Books	46%	52%	2%	47%	49%	4%	53%	44%	3%
Papers / magazines	20%	61%	19%	33%	58%	9%	60%	39%	1%
Television	32%	50%	18%	36%	51%	13%	51%	42%	7%
Radio	15%	61%	24%	17%	65%	18%	21%	68%	11%
Brochures, etc.	16%	39%	45%	22%	43%	35%	35%	50%	15%
CD-ROM	25%	48%	27%	20%	51%	29%	6%	43%	51%
SMS / mobile	9%	22%	69%	16%	30%	54%	14%	34%	52%
Sample size	1616			2932			3212		

Source: *WA 2003 Youth Survey*

circumstances. Concerning who young people consider to be the major influences in their lives, one could predict the high standing of parents (94% responded “a lot” or “some” influence) and friends (96%). Less predictable may be the very high regard many of our youth hold for their teachers and lecturers, with 78% of these young people saying teachers had “a lot” or “some” influence in their lives. This total is higher than the respondents in the survey reported for other relatives, sports coaches and other popular figures.

In a sense, these findings support the old notion that "the best salesman 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 influencers. 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 would 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 to influence 30,000 of their

Table 2:
Major influences of opinion, 2003 compared to 2000.

Influencers of opinion	2003 Total			2000 Total		
	A lot	Some	None	A lot	Some	None
Parents*	54%	40%	6%	51%	43%	6%
Friends	44%	52%	4%	40%	55%	5%
Teachers / lecturers	19%	59%	22%	16%	56%	28%
Other relatives	15%	55%	30%	-	-	-
Sports coaches	13%	31%	56%	13%	32%	55%
Newspapers	9%	59%	32%	9%	59%	32%
Artists / performers	9%	36%	55%	9%	36%	55%
Rock / pop stars	9%	32%	59%	11%	33%	56%
Youth leaders	9%	31%	60%	8%	33%	59%
Sports stars	9%	27%	64%	12%	31%	57%
Religious leaders	9%	24%	67%	9%	24%	67%
Television and radio personalities**	8%	47%	45%	-	-	-
Politicians	4%	29%	67%	5%	23%	72%
Sample size	7919			10475		

* In 2000 this category was 'parents and other relatives'.

** In 2000 these categories were separated and are not reported here.

NB The table will not sum to 100% as multiple responses were allowed.

Source: *WA 2003 Youth Survey*

children. We can say with great confidence that the teacher-student relationship is real and that these relationships already exist (in the Western Australian instance) between several hundred WA teachers and several tens of thousands of WA school students.

It seems that existing teacher-student relationships present an opportunity too good to pass by. Recognising that teachers come in all sizes, shapes and flavours, exactly which teachers are best positioned to maximise their influence with potential young researchers and employees?

Career Drivers: What motivates students to do post graduate research in mineral resources?

Teachers are heroes

That teachers can have a strong influence on their students is a concept as old as mankind. Certainly Plato reflected a great deal of though that Socrates (his teacher) shared with him. The influences of Buddha, Jesus and Confucius are notable in that they still exert an influence on many centuries after these teachers walked the earth. Surely most people could offer anecdotal support for the notion that some teacher at some point in their lives had a significant influence on their personal development.

But how far does this influence go beyond the classroom? A study looking at what motivational factors affects career choice in the minerals resource and energy sector employed a questionnaire exploring six potential career drivers (Churach & Rickards, 2003). Though the questionnaire features 36 questions divided into 6 scales (financial, academic, relationship, lifestyle, altruistic and personal esteem), it also includes several open-ended questions concerning influences of teachers on career decisions. The number and type of responses to these open-ended questions offers strong support concerning the value of school teachers as a valuable means of reaching secondary students with information concerning career choices:

> *The research is on-going and the sample has now over one hundred respondents, 82% of whom are currently working in the industry with the remaining being students of either metallurgy, chemical engineering or mining engineering. 46% of these researchers, managers and scientists have taken the time to volunteer the positive effect that one or more of their teachers had on their career choice ("My high school science teacher always encouraged me and challenged me to ask why…"). 16% of those in this sample spoke of teachers having a negative effect ("I wanted to prove that I could do it even though my high school chemistry teacher said I never could…"). The salient point of it all is that nearly two-thirds of the professionals within the mining, minerals and resource processing industry voluntarily took the time to write of the influence of one or more of their teachers on their decision to enter the industry. In most cases these teachers were secondary and were science teachers. Interestingly enough, only one respondent out of the 115 in the sample mentioned a guidance councillor."* (Churach, 2004a, p. 30)

It seems that the target audience that would allow industry to maximise its leverage in an attempt to influence young people would be secondary science teachers. The teachers already have existing relationships built with many of their students and both teacher opinion and input is highly valued by most of these young people. Additionally, each teacher may see 150-200 students in the course of a week, so if positive experiences can be provided for secondary teachers, there is every reason to believe their students will view the industry in increasingly more positive terms. Even more, for those students most likely to be open to careers in the mining and mineral resource sector in many cases look to their science teachers as heroes.

A recent study on the state of science education in Australia, "*The Status and Quality of Teaching and Learning of Science in Australian Schools",* was presented to the Department of Education, Training and Youth Affairs in Canberra in 2001. The researchers offered an in depth report on the state of science education in Australia and pointed time and again to the teachers being the key to any positive change within schools. Amongst the many recommendations made by the team was the following, underlining the value of including the wider community in producing the highest quality education:

> *Teachers working alone in their classroom can make small steps towards change. Teachers working together can make larger strides. Schools collaborating make a greater impact still. But quality science education curriculum and professional development resources are very expensive and require the very best expertise to develop. Collaborative ventures that pool the financial and human resources from a number of jurisdictions have the potential to produce the world-class materials that are required for a contemporary, relevant and engaging science education for all students. (Goodrum, Hackling & Rennie 2001, p. 169).*

In a time when education budgets undergo cuts and government systems continually insist on more for less, the time is ripe for alternative ways of acquiring the resources and learning experiences that will result in greater excellence among our teaching staffs.

How does an industry reach out to teachers?

The Technical and Vocational Education Initiative (TVEI) instituted by the in the United Kingdom in the 1980s was an example of a government attempt to involve industry in teacher development PD). Initially many teachers were quite suspicious of potentially devious motivations and hidden agendas that industry sponsors may bring into schools. Was it possible controversial industries merely wanted to change their images? (Keith, Lakin & Callaghan, 2000) More, is it possible that industry sponsors may view teachers as over-paid and under-worked part of the public sector bureaucracy?

If industry input to teachers' professional development is to have appositive impact on teachers, it must be based on trust and mutual need between the industry sponsors and the teacher participants. That teachers (particularly on the secondary level) need "real world" experiences with which they can build upon their theoretical base is apparent. Conversely, the necessity for industry to have any input into the ever-expanding breadth of knowledge in a 21st century classroom is equally important for the simple reason that "Teachers of science will be the representatives of the science community in their classrooms" (National Research Council, 1996, p. 61).

No doubt school-industry partnerships can thrive on an *ad hoc* basis, though the success of these arrangements may often be dependent on the energy and personalities of a few prime players on either side of the fence. The Cooperative Research Centres Program instituted by the Australia government in 1990 attempts to change the research culture of the country. The aim can be stated simply, though the implementation of their charge is much more difficult. In brief, CRCs are meant to bring together the expertise of industry, research organisations, educational institutions and Federal and State government agencies together as core participants in each centre to address specific research priorities in a variety of commercial and public interest areas. The ultimate goal of the CRC Program is to boost the competitiveness of Australian technology and to help ensure the country maintains and extends its science and technology base well into the 21st century (Churach, 2003).

The point has been made previously in this paper that one of the most important wealth-producing industries in the Australian economy (mining and mineral resources) has experienced a great decline in young people indicating interest in careers within the sector. Many in the industry ask if anything can be done to stem the tide and somehow develop greater interest among young people in this challenging and profitable field.

Professional development experiences for secondary science teachers

Beginning in 2003, two Australian Cooperative Research Centres and Murdoch University Extractive Metallurgy staff initiated a program offering a series of on-going professional development activities for secondary science teachers. The point of the program is to stress "positive activities", with great emphasis placed on the plural "activities". Other programs offer teacher professional development activities and some can be quite intensive. The Colorado Mining Association and Colorado School of Mines have offered a summer teacher program going back several decades (Witkowsky, 2004), but even this program calls for a one-time course run for a group of K-12 teachers. The Murdoch-CSRP-Parker Project places the emphasis on the on-going nature of the program 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 form 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 and work experiences) over a period of

time. 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 (a few years) 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 industry. There is support for this approach in the literature. One project carried out in Alberta, Canada, indicated more positive outcomes when career options became infused into the curriculum and not taught as separate items (Millar, 1995). This research indicated the need for a strong dose of professional development to be provided to teachers.

Certainly, teacher professional development is in the realm of various state education departments, but in the area such as mining and minerals resource processing, little in the way of real professional development can be expected from government sources. The reason for this is two-fold: First of all, education departments tend to focus more specifically on process issues (e.g., in WA during the past several years, the schools have been mandated to move to the new outcomes-based curriculum) and nearly all of the monies provided fund those type of professional development offerings. Secondly, few academics and even fewer educators have any practical industrial experiences involved with mining, minerals and resource processing. It seems that the time is right for a cooperative venture involving school teachers with both academia and industry personnel.

Since the program's inception in April 2003, a total of ten professional development days and a variety of tours of research facilities and industrial site visits have been offered. The following activities have been offered:

- "The Chemistry and Physics of Extractive Metallurgy" (6 short-courses)
- "Advanced Extractive Metallurgy" (2 short courses)
- "Online Interactive Learning – Providing a Minerals Industry Context for Secondary Student Learning Workshop" (2 short courses)
- Tour of CSRIO Minerals research facility in Perth
- Visit to the atomic force microscope (AFM) at Curtin University
- AngloGold Ashanti sponsored visit to Sunrise Dam Gold Mine and Processing Plant
- School, Community and Industry Partnerships in Science (SCIps) Projects with two schools (2 projects)
- 2003, 2004 and 2005 Parker Youth Lectures (7 lectures)
- Northwest Science Teacher PD tour (3 remote towns in 2004)
- Science Teachers Association of Western Australia presentations (2003, 2004)
- Diploma of Education Metallurgy students 90-minute Extractive Metallurgy Laboratories (2004, 2005)

The introductory short course entitled "The Chemistry and Physics of Extractive Metallurgy" is held in the Extractive Metallurgy laboratories at Murdoch University. This one-day workshop allows science teachers to spend the day in laboratories exploring three key areas: mineral processing (physically separating ores), pyrometallurgy (the use of heat to extract metals) and hydrometallurgy (the use of water to extract metals). Because these teachers have voluntarily given up a day of their term breaks, the Centre for Sustainable Mineral Processing, Murdoch University and Parker Centre underwrite the cost of the staffing, the materials used for the professional development activities and the tea, lunch and a wine and cheese end to the day. Teachers go home with a bag of teaching materials including posters, CDs, and the like along with a tin ingot they pour and chemist's spatula they gold plate.

The first PD received such positive feedback that an additional "Advanced Extractive Metallurgy" course has been offered the past two years. This one-day PD has teachers begin the day with a rock-solid sample

of ore which they process into a purified metal by the end of the workshop. Murdoch teaching staff and researchers offer expert "consultancy" services throughout the day.

The Minerals Council of Australia has also contributed a series of on line learning objects involving the "Down to Earth Series" of science-based learning experiences ("learning objects") utilising the Australian minerals resource industry as a context for self directed learning. Several one-day PDs have been offered around these computer-based interactive multimedia educational tools with part of the day spent working in the computer lab and the rest of the day offering lab work to supplement the learning objects.

There have also been a variety of tours to industry and research partners' facilities, student lectures, presentations to the science teachers' professional organisation and to Diploma of Education students. The CRCs were also involved with doing a travelling teacher PD tour of the northwestern part of the state during 2004. A total of some 150 teachers or student teachers have been involved with at least one of the PD offerings and at least half have been involved in multiple activities.

Early Results

Quantitative outcomes of the PDs

After the second year that the program was running, a survey for teachers was developed using questions designed to assess a series of attitudes secondary science teachers hold about the mineral resource industry and how the professional development program may affect these attitudes. The survey was reviewed by the academic staff at Murdoch University Extractive Metallurgy and at the Science and Mathematics Education Centre at Curtin University of Technology to determine whether it covered a range of issues facing both the industry and teachers in Western Australia. The survey consists of 16 questions each of which calls for the participant to respond twice, once based on their point of view before the first professional development they attended within the program and a second time from their point of view today. Respondents answered numerically on a 5-point Likert Scale with 1 being "Strongly Disagree" and 5 being "Strongly Agree" (see Appendix I). Though a running registration list of approximately 100 participating teachers was kept over the three years, it did not include student teachers and teachers contacted during short (50-minute) presentations at Science Teachers Association of Western Australia (STAWA) presentations. Initially 78 surveys were sent to teachers and 12 were returned because teachers had changed jobs or otherwise could not be contacted. Of this total of 66 surveys, the data reported here is based on a sample of 43 surveys returned (65%). Results of all the surveys were tallied to find the average response for each question both before and after the respondents participated in any PDs. Though actual values of responses can not be taken as a meaningful reflection on the PD program, the shift in average response can be interpreted as a change in teacher attitude towards the industry. A positive shift in score is interpreted as a positive shift in teacher attitude towards the industry and a negative shift in score is viewed as a negative shift in teacher attitude towards the industry. Results of the survey are show in Table 3.

A two tailed t-Test for paired samples was run on each of the 16 question sets in the survey and in every case 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 PD work they had done than with any kind of chance occurrence. Certainly the qualitative results reported below seem to support this finding.

It is interesting to note that the two greatest shifts in response where with the teachers' overall knowledge of the industry (1.40) and teachers getting to know and network with scientists (1.28). Other notable shifts in teacher attitudes were in teacher willingness to provide career information

Table 3:
Mean teacher response to survey questions.

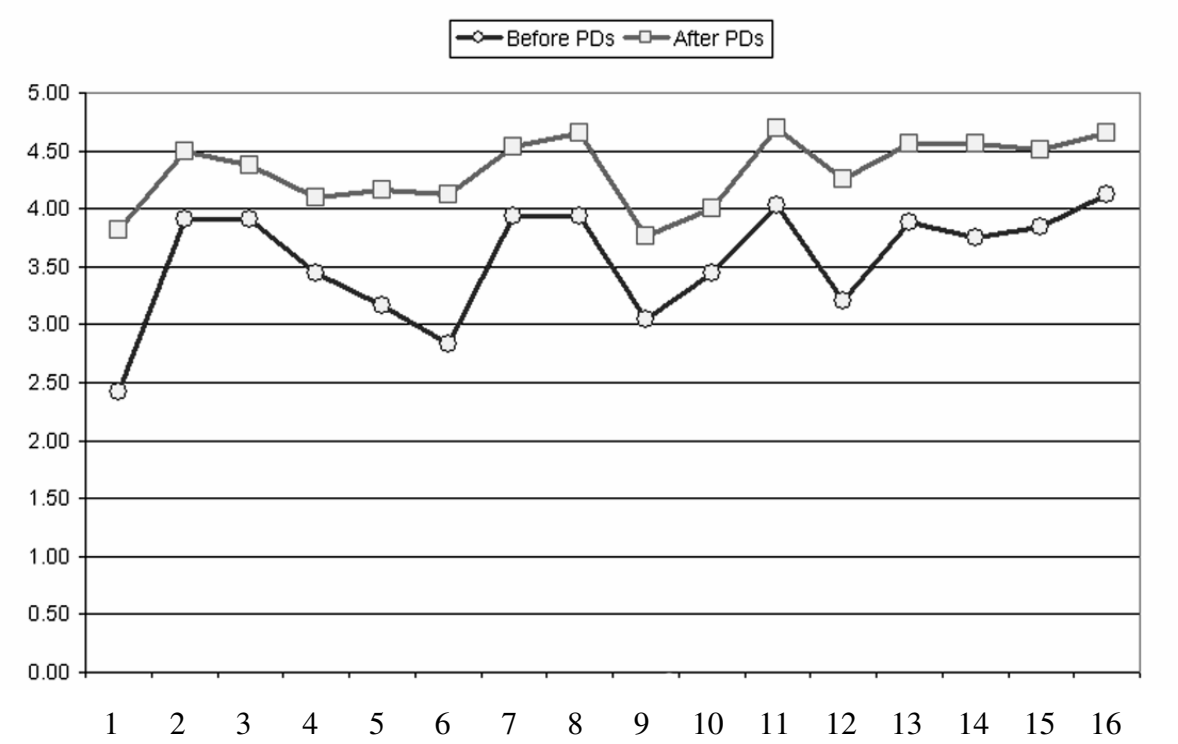
Survey Question	Mean response before any PDs	Standard deviation	Mean response today	Standard deviation	Shift in attitude score
1. My overall knowledge of the Mining and Mineral Resource industry is very extensive?	2.42	1.01	3.81	0.93	1.40
2. I believe that careers in the Mining and Mineral Resource industry are worthwhile recommending to my students.	3.91	0.87	4.49	0.74	0.58
3. I have a very positive attitude towards the Mining and Mineral Resource industry in Australia.	3.91	0.81	4.37	0.79	0.47
4. I believe an excellent way to solve environmental problems can be found through Mining and Mineral Resource research.	3.44	0.93	4.09	0.72	0.65
5. I use examples of the Mining and Mineral Resource industry in my classes frequently.	3.16	1.19	4.16	0.69	1.00
6. I know a scientist I can e-mail or phone to get information concerning a mineral processing or chemistry question.	2.84	1.25	4.12	1.00	1.28
7. I consider a Mining and Mineral Resource in Australia to be a modern, high-tech industry.	3.93	0.77	4.53	0.59	0.60
8. I think that a Mining and Mineral Resource industry offers an exciting career path for young people.	3.93	0.99	4.65	0.53	0.72
9. I talk to colleagues and friends about issues concerning the Mining and Mineral Resource industry in Australia.	3.05	1.05	3.77	1.02	0.72
10. I believed that people in the Mining and Mineral Resource industry care about the natural environment.	3.44	0.96	4.00	0.76	0.56
11. The more teachers do hands-on activities, the better they will understand the Mining and Mineral Resource industry.	4.02	0.64	4.70	0.51	0.67
12. I provide information to students concerning the possibility of a Mining and Mineral Resource major at university.	3.21	1.08	4.26	0.76	1.05
13. I have a positive view of career researchers and scientists in Mining and Mineral Resource industry.	3.88	0.85	4.56	0.50	0.67
14. Getting a bit of an “inside view” of the Mining and Mineral Resource industry makes me a better teacher.	3.74	0.85	4.56	0.50	0.81
15. Getting a bit of an “inside view” of any Australian industry makes me a better teacher.	3.84	0.90	4.51	0.55	0.67
16. PDs that offer a maximum amount of science content-oriented material make me a better classroom teacher.	4.12	1.05	4.65	0.61	0.53

n = 43

to students (1.05) and to use mining and mineral processing examples in class (1.00). Standard deviations are also listed for each scale indicating the spread of responses. In the four attitude shifts mentioned here, the small stand deviations implies that participants showed similarly large changes in responses, exactly what would be anticipated if a strong association existed between teacher PDs and attitude changes.

Figure 1:

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



Qualitative outcomes of the PDs

Studies by Shrigley (1974) and Sunal (1982) have pointed to the fact that involving science teachers in industry-related field experiences development activities not only affected attitudes towards science in general, but also attitudes towards science teaching changed in a dramatic way. Much of the qualitative feedback received in this program supports the positive effects of these professional development offerings on teacher attitudes towards the industry. If success can be measured in enthusiasm, then the program has been a smashing hit.

Additionally, teachers who became engaged in the professional development program tended to continue their involvement with two, three or more activities. Of the 43 teachers responding to the survey reported on, nearly two-thirds (26 of 43) opted to participate in several of the offerings. Though the average number of PDs the teachers participated in was 2.28, some teachers completed 4, 5 or 6 of them. In one case, a high school chemistry teacher took part in 7 different activities. It is notable to point out that in every case except one during school time “Parker Youth Lecture”, these PDs occurred outside of school hours and thus the teachers were voluntarily giving up their own time.

One chemistry teacher has attended seven different activities over the two years. “It is very generous of the Parker Centre to provide teachers with the opportunity to see chemistry in an industrial context and to be able to understand another employment avenue for our students. For the teacher to be able to relate the course to real world situations seems to bring it alive for the kids.” This teacher has also made use of the network developing through this initiative to communicate with academic staff at Murdoch and both CRCs and has organised visits for his own students to the university.

Another chemistry teacher had this to say about one of the one-day PDs she completed last year: “I thoroughly enjoyed this course ─ it was great to be able to do some new hands-on experiments. The gold plated spatula has been a real hit at school.”

One Head of Science Department at a Perth college spoke highly of her visit to the Sunrise Gold Mine site. “A million thanks for enabling me to have the most wonderful experience by visiting the mine last week ─ it was really the high point of my holiday. I have been enthusing my family and students with the story ever since...”

A professor in science education at a local university also went along to Sunrise Dam. “I have gained long term residual value from my visit to the Sunrise Dam mine site. Not only has it provided an on the ground authentic experience of the people and processes that are the heart and soul of a successful mining operation, but it has provided a clear picture of what a significant contribution to the economic wellbeing and community life of our country this industry offers. It is significant and yet is a quiet achiever in terms of public knowledge.”

And the enthusiasm comes from the providers of the experiences, too. The General Manager of a global gold producing company says that it is critical for the mining industry to demonstrate to the teaching profession that the Australian mining industry is the world leader in its technological, safety and environmental practices and that it provides exciting and stimulating careers in a truly global industry. "We take pride in what we do and enjoy communicating the excitement of our industry and its benefit to the broader community," he says.

One of the professors at Murdoch University who has volunteered a great deal of time to organising and implementing the teachers PDs pointed out that, “If no one takes the time to provide these kinds of experiences for the high school teachers, then we can't expect their students to realise that many opportunities exist in this exciting industry. We in Extractive Metallurgy have been delighted with the opportunity to partner the … [CRCs] in this valuable initiative. Graduate prospects have never been better than they are currently due to the continuing boom in global metal demand."

A program manager for Australia’s Commonwealth Scientific and Industrial Research Organisation (CSIRO) commented after taking a group of teachers on a tour of a mineral research facility, “It was terrific to see the genuine enthusiasm the teachers showed for our research. This was very evident from the questions asked during and after their visit. Enthusiastic science teachers are essential for promotion of science at school and the supply of quality undergraduates to universities. CSIRO can supply great career opportunities for science graduates, but it can't happen without good science teaching in schools.”

Conclusions

Two-plus years into this project, there are several conclusions that can be drawn with a reasonable degree of confidence. Firstly, the teachers who have participated in one or more of the teacher professional development offerings have offered a great deal of verbal feedback in support of the program. As pointed out previously, many teachers opted to give up their free time during school holidays or in the evenings to do more than one activity. The network that has formed is lasting in with some teachers has endured over the entire two-and-a-half years of the project.

Secondly, the shift in teacher attitudes towards a more favourable perspective of the mineral resource sector was significant in all sixteen questions asked in the survey. This suggests a strong association between teachers participating in the professional developments and a positive shift in their attitudes towards the industry.

Finally, the attitude shifts represented by the last two questions (15 = *Getting a bit of an "inside view" of any Australian industry makes me a better teacher* and 16 = *PDs that offer a maximum amount of science content-oriented material make me a better classroom teacher*) seem to indicate that the teachers in this sample believe more professional development offering a better insight to "real-world" science applications (eg., industry) would result in improved teaching on their part. Though this project is sponsored by the mineral processing sector, all industries dependent upon young people studying the fields of science, technology, engineering and mathematics could benefit from sponsoring teacher professional developments as a vehicle for reaching out to young people.

The Way Forward

The teacher program is being expanded to a second state, Queensland. It is anticipated that a larger sample of teachers will allow a more meaningful insight to any associations between professional development activities for teachers and the attitudes they hold towards industry sponsors. Additional data will be obtained to assess whether or not the attitudinal change is "passed on" by participating teachers to their students. At this point there is anecdotal evidence that this is the case, but using before-after questionnaires with students could offer insight to this question.

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Appendix 1

June 2005

Murdoch University Extractive Metallurgy / CSRP / Parker Centre Teacher Professional Development Program Feedback Survey

I am gathering data in an attempt to measure the effectiveness of the Murdoch University / CSRP / Parker Centre 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 with us and secondly from your perspective today after having participated in one or more of these PDs.

A returned envelope has been addressed and stamped for your convenience. Your feedback will help to make our professional development work more supportive of you and other teachers in the future.

Thank you in advance for your input.

Regards,
Dan Churach

Name _____ **School** _____
(optional)

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

Intro PD ☐ Advanced PD ☐ On Line Learning PD ☐ CSIRO Tour ☐

Industry Tour ☐ Atomic Force Microscope Tour ☐ Parker Youth Lecture ☐

Any Other Activity sponsored by the above organisations? _____

		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. Today	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

PLEASE TURN THE PAGE TO COMPLETE THE OTHER SIDE…

		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. Today	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. Please return form to Dan Churach, Murdoch University, MURDOCH, WA 6150