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IMWA INSIGHTS

Mine Water Research: Enhancing Mining Industry and Academic Collaboration

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Abstract A cooperative relationship between industry and academia can be mutually beneficial, yet there is typically little engagement between academic researchers and industry in the mine water field. Many potential obstacles may inhibit interaction, including a lack of trust and reliability, a lack of understanding of how both sides operate, alternative viewpoints on how research should be structured, and misunderstandings of academic and industry's performance measures. These obstacles are not insurmountable. A clear understanding of each parties' ways of working, goals, and limitations can pave the way to mutually beneficial relationships that will improve mine water practices. Industry consultants with research training and project experience may help facilitate these relationships by identifying industry research needs and academic research opportunities, reviewing grant applications and funded deliverables, and through post-graduate student co-supervision.

Introduction

Mine water presents novel and vexing problems for the mining industry that are increasingly being addressed by academic researchers (Wolkersdorfer 2004) who are typically either directly funded by industry, or are funded through government schemes that may or may not have ancillary support from industry. However, academic and industry staff typically engage infrequently, and even then may achieve limited success in resolving industry's mine water research needs. This paper presents key issues that limit engagement between academic research and industry's needs for mine water research, and discusses potential solutions from both parties' perspectives. Although it discusses research primarily as afforded by academic (tertiary institute) providers, many of the discussion points, conclusions, and recommendations will also be translatable to government researchers and private providers. Approaches and strategies that industry and researchers might consider if they wish to embrace the many mutually beneficial research opportunities available are also suggested.

Academic Experience with Industry

Societal engagement is increasingly a requirement of academic research worldwide. Also, the industrial relevance of research findings is typically a key consideration for academic faculties housing applied science and engineering departments. Nevertheless, many universities and their academic staff are struggling to meaningfully engage with their industry counterparts, in part because their industry equivalents are also facing challenges engaging with these academic institutes. Meanwhile, industry-funded research that simply duplicates run-of-the-mill services already provided by consultants is anti-competitive due to the academic institution's government financial support. Providing basic consulting services as academic 'research' is disingenuous to both the mining company and ultimately, the underwriting tax payer, and is unlikely to provide long-term benefit to the industry.

However, one of the key obstacles higher education faces is simply that most academic staff have not

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previously worked in, or directly with, the mining industry. Similarly, although some industry staff may have been involved in academic environments before (such as being a research student, research assistant/associate, or even a post-doctoral role), these afford little experience in the research funding-application and project management processes. In many countries, the career paths between industry and academia are regarded as very dissimilar, with obstacles preventing the ready movement between graduate career paths of government, academia, and industry. Key to these obstacles is a lack of recognition of time spent in the different career paths, even though aspects such as project and staff management, client engagement, and technical ability are highly relevant to each career.

As a result, the mining industry often doesn't understand why some industry-supported projects do not engender interest and support from academics. As we shall see, it is also a key reason why industry-funded research deliverables sometimes differ from industry expectations. For the world of academic publishing is still an academic's major driver, even though increased attention is being given to student evaluations and academic service to the university. The situation is completely different in industry, for while some industry partners recognise the marketing value of conference presentations and publications, few realise that the large amount of time and effort that academics expend to achieve citation-indexed journal publications is because the number of these are their primary key performance indicator (KPI) for promotion. Therefore, industry and academia may not share the same endgame vision: conference presentations and industry articles may be desirable outcomes for academics, but peer-reviewed papers are a *necessity*.

Industry-funded research may also be better suited to applied publications. For example, case-study work specific to a region, commodity, or mining type is less transferable than research that addresses science and engineering fundamentals. Consequently, many of the publications that publish such papers will not receive the same level of scientific acclaim (e.g. the ubiquitous citation indices) as a pure science publication. [Editor's note: this journal welcomes case studies, as we attempt to serve both researchers and practitioners, and yet we have a very good citation index score that continues to increase.]

Many academics also do not understand industry, as academics usually have very limited experience working in or within industry. It is unusual to see career paths from academia to industry and even less common to see career paths from industry to academia, even for very application-oriented departments.

Simple understandings, such as the implicit requirement for profitability (either directly through cost savings or improved productivity, or indirectly through marketing and business development opportunities) may be lacking in the approach and outcomes of academic research. For academics, exposure and a research output of a publication increases the potential for another research grant, while for industry, it is typically solutions to problems that increase profitability, be they current or potential processes or strategies.

Academics have been trained not to offer absolute interpretations of their results (and most likely chastised by their peer reviewers when they did), and so are cautious; they will rarely offer an unqualified statement or a definitive statement. They typically feel that they do not have enough data for unequivocal judgment calls, and will instead consider their contribution an addition to the current state of mine water knowledge, processes, and approaches. This can make the mining industry think that academics are too equivocal and pedantic, while the reality of the international peer-review publishing process is that this caution is exactly what is required of successfully publishing academics. So, academics may feel very uncomfortable working and advising when not in a robust knowledge position, while in industry, significant decisions often have to be made based on sub-optimal knowledge.

These can be quite disparate goals if common elements to mine water research are not defined and agreed to prior to researcher engagement. Academics who are aware of industry's needs and operating manner can function as mentors for academic staff not used to working with a company to achieve common goals. Equally, research-experienced (not just research-qualified) mining and consulting industry staff can be key to developing mutually-beneficial research relationships between the mining industry and academia. Formalised relationships with common goals, such as technically-oriented mining professional associations, may assist in developing mutual understandings for new research projects.

Meeting Industry Objectives

Research funders have occasionally found that academics have accepted grants but then undertaken unrelated research in the academic's field of interest or in the area of research that the academics were working on prior to receiving the funding. Too vague of a research project and/or insufficient tracking of research progress may fail to detect deviations in scope, and can lead to final research output that does not have the quality or relevance intended by the research funder. If industry-funded research is to be successful, then corporate objectives must be met; the mine water problem(s) have to be addressed and hopefully solved. If the academic uses the funds to support post-docs or to continue projects that do not provide direct value to the research funder, the industry will not have received

good value. Meanwhile, industry-naive researchers may feel they provided a good research product, unaware that it failed to meet the funder's objectives. Academics ignore this basic principle at their peril; when industry feels it has not received good value for their research dollar, they will likely discontinue further funding of both the researcher and the research institution thereafter.

Sometimes, mine water industry research funding does not last long enough for truly meaningful and significant contributions. Often, the funding only lasts for a few years, if that long. However, the time required for a Ph.D. student to develop expertise in this area and complete (let alone publish) their Ph.D. may mean that results and publications occurring at the tail-of the research project are not as thorough or as timely as what would have occurred if the project funding lasted longer, perhaps because post-graduate students did not have enough funding to complete their degree, or left for a job offer without having published any papers. Indeed, delays in developing a working knowledge of mine water may compound the risk of failed output, as it may reasonably take 1–2 years from initial funding to develop sufficient knowledge and meaningful results to warrant successful academic (i.e. citation indexed) journal publications. The key outcome of this constraint is that the nature of studies that academic researchers can do for industry may be limited by this inertia in developing basic industry knowledge. A partial solution is for an academic supervisor, acting as the project leader, to build in redundancy to a research project by overlapping thesis topics, breaking a larger programme into smaller output components, etc. Experienced industry consultants may assist through co-supervision arrangements as university adjunct positions. This solution may be undermined by academic operating environments and structures that either do not support or otherwise fail to realise the importance of these research requirements.

Requiring that industry-funded research first and foremost provide benefit to the industry partners would help direct research efforts. The best way to achieve this may be for industry to first identify broad areas for research where there is also a good scope for publication. Research-experienced members of industry can help to direct these research funding foci. Academics can then specifically discuss with potential funders how they propose to contribute to this area of research need. Provided that suitably experienced industry or academic reviewers are available, peer-review of these grant applications can work very well in this regard. Research can then be proposed, via investigation of carefully considered and clearly articulated knowledge gaps, into clearly stated research questions accepted by the industry-funding body.

Researchers should then be required to disseminate their results in a timely manner as part of the funding arrangement, in a style that is easily understood by industry, the scientific community, and any other significant stakeholders identified by industry. These stakeholders may include regulators, indigenous groups, interested non-government organisations (NGOs), or even the general public. Peer review of final research products is an important step often overlooked by funding bodies to provide quality control for research relevance and quality.

Placing a greater emphasis on the track record of a competent and relevant researcher who has previously received industry funding may be a better approach than funding a research proposal solely on its independent merits. Frank performance feedback from industry, with opportunities for the researcher to discuss and explain negative views on performance, is required. Researchers that have established experience and respect in the industry sector, and are responsive to industry requirements and sensitive to the mining industry's needs should reasonably have the potential for an industry-funded research relationship spanning their career, to mutual benefit.

Industry Expectations

Industry often looks to academic researchers for a number of reasons. Cost is often a key perceived advantage of academic research over services offered by consultants and other industry technical professionals, including in-house expert staff. However, this cost must be compared to the resultant deliverables, which are often typically defined in broad terms at the funding stage, with further approach and deliverables left up to the researcher. As such, the value to industry, when considered in terms of relevancy and output, may be very poor. For example, fully-funded post-doctoral appointments to address industry-funded research will primarily result in either expansive research reports that are not peer-reviewed, or 1–2 papers that are academically peer-reviewed, but less relevant and much narrower in scope. Such funding may not represent competitive value for research dollars compared to what may be provided by internal or consulting research resources. Furthermore, delayed, incomplete, or misaligned/irrelevant research deliverables represent a significant loss of time and opportunity to industry funders. Industry-funded chair appointments that leverage other industry, research institution, or government funding may offer much better value for such support.

Academic researchers may also be perceived as an objective third-party, particularly where stakeholder-sensitive issues are being explored. However, academic researchers may be similarly biased. Industry-funded academic research, where funding is often directed to a single academic who acts as project manager or director/lead researcher/project accountant, or all of the above roles

together, may not be peer reviewed. This differs markedly from other expert technical advice, such as is offered by industry consultants where peer-review is generally undertaken for each deliverable or technical communication or advice to the client. Although these review processes may be limited by the established internal practices of the consulting company, it does offer a sanity check on the advice being offered. Furthermore, benchmarking between different offices, regions, and consulting firms can address the internal review limitations. Also, a consultant's advice is typically supported by professional insurance and/or professional certification and accreditation.

University Expectations

Despite articulations of growing interest in meaningful contributions to contemporary society, universities and their primary funding bodies (often state and national level governments) are still often reticent to engage with industry unless industry offers research funding as cash. Younger institutions may fail to recognise the long-term but less tangible value that industry engagement offers, and therefore may not support academic staff in developing such ventures to begin with. Increasingly, though, research income (including industry funding) received by a government-funded or academic research institution is seen as a KPI for research productivity and quality, for which they may be financially rewarded (e.g. performance awards), regardless of actual research output, peer-reviewed, citation indexed, or otherwise. Such incentives encourage research directed at meeting this internal KPI, i.e. deriving external income, rather than the KPI of the industry funder, i.e. industry-relevant quality research delivered in a timely manner.

Acceptance of industry funding for some projects may mean that higher prestige scientific outputs are not required; that is, the academic KPI of publication is not needed if industry simply needs a problem solved. Also, a priori confidentiality agreements may limit dissemination of some research finding, which may be particularly problematic for early research-career staff such as graduate and post-graduate students and post-doctoral staff. Although this may benefit the industry partner through exclusion of research findings from a competitor, such intellectual property protectionism inevitably impedes development of mine water practice as a whole.

If a high-quality research output is still desired by the academic institution or their funding source, then either party may have to provide additional funding, e.g. salaried time to write-up industry reports into a paper. Alternatively, a strategy to interpret applied research results more in terms of discipline fundamentals may produce a paper that can be accepted for publication in a higher citation-indexed journal.

Alignment of Industry-Academia Expectations

The mining industry has relationships with professional scientific advisors (such as consultants) that (much like an accountant or lawyer) they can bring their problems to without fear of prejudice or unauthorised public exposure. There may not be such trust of academic researchers, particularly those unknown to industry. This is due, in part, to a lack of understanding of the aforementioned disparate research objectives and from little long-term engagement between the parties. Professional industry certification and accreditation organisations are unlikely to be able to address these problems. However, academic and industry bodies of mutual interest, such as the International Mine Water Association (IMWA) provide valuable interaction between all three groups, academia, consultants, and industry.

A common problem many academics face when working with industry may be that industry's experiences with technical mine water experts may previously only have been with professional consultants. Hence, industry may perceive the relationship with academics to be the same: the industry pays an expert, the expert solves the problem to a satisfactory state, and confidentially reports back to industry. No more complex relationship is required or expected. Conversely, with their critical thinking training, when presented with a problem, academics may see *more* problems rather than solutions, and may find it hard to progress to the broad and general advice that industry needs for a satisfactory resolution.

There may also be an industry distrust of academic researchers due to confidentiality concerns. If an expert can solve their problem, industry is often prepared to make public that they had a problem and that they solved it in an innovative, sustainable, etc. manner. Conversely, academics may be prepared to publish the finding of an environmental problem, even if they do not have a solution, potentially resulting in negative corporate exposure. In contrast to industry marketing advisors who would strongly caution against or reject such a publication, this behaviour may be encouraged by university marketers where a media focus may be considered beneficial to bringing attention to and/or enhancing the reputation of the institution.

As part of industry funding and research involvement, both industry and academia should also be committed to producing and mentoring the next generation of experienced and qualified people that will be able to service the future technical needs of the industry.

Research Ethics

Researchers and their funding bodies have found to their detriment that failures to adhere to standards of conduct can be highly publicized. However, misdirected topics and inappropriate research approaches can still produce damaging legacies to both industry and researchers and consume significant amounts of government and industry research funder's time and resources. Equally, incorrect or imprecise research findings may mislead subsequent research by limiting, or even reversing progress in the mine water research field. Both scenarios may also bring concurrent and future industry-funded research into disrepute.

Consequently, all mine water researchers funded by industry grants must maintain high standards of intellectual honesty and integrity, with rigor in all scientific and scholarly activities. The ethics and professional behaviours of industry-funded research undertaken by formal institutions should primarily be managed by those institutions under the funding contract. Key areas for discussion and delegation of responsibility during funding contract development should include the following at a minimum (Kennett 2013).

- Due credit must be given to prior work and authorship on any resulting work.
- The work should be underpinned by a thorough literature review to demonstrate it is not simply repeating already available findings, formally published or otherwise.
- The proposed scientific methodology should be appropriate, and the results should be useful to industry in a tangible, not esoteric, way.
- Intellectual property and any potential conflicts of interest must be managed and clearly documented.
- Health, safety, and environment considerations (HSE) should be fundamental to all industry-funded or sanctioned (e.g. with in-kind use of data or field site support) work practices. It is therefore vital that industry-aligned HSE practices are followed in all research projects, be they on- or off-site.
- Researchers must obtain all approvals from relevant ethics committees, safety, and other institutional regulatory bodies, as required.

Work completed with industry funding or other involvement is further expected to meet all scientific standards and accepted practices of the discipline concerned. Researchers who are negligent are placing their reputation, the industry's reputation, the work of their colleagues, and the public's confidence in the science at risk (NAS et al. 2009).

Conclusions

In addition to project milestones, project staff funding, etc., an understanding of both parties' objectives should be clearly discussed and documented prior to any formal engagement of research services. Corporate legal teams and university research and development departments can all assist in this regard. However, they must be open to compromise from how things 'normally' work within their respective organisations, given the novel relationship that industry-funded collaboration may mean to both parties.

The implications of legal protection for copyright and later use by the researcher must be considered and clear intellectual property agreements explicitly considered and documented before funding occurs. Academics may wish to work more as consultants (for instance, the work may not have publication potential), or more as academics (with a priori industry agreement that this work is new/interesting/relevant to the broader industry or discipline and with clear intent to publish it as a research output). Although it may appear of little consequence to a company that is focussed on the research application, publication should be encouraged as a quality-control exercise of the technical practices underpinning the research outcomes. This has been shown to be of particular value where third party validation of the research findings is required, such as by stakeholders.

One approach to meeting industry-funded research output requirements may be to first present the research findings in an industry forum as a conference presentation and/or paper, or similar. Then the research can be broken down to more fundamental principles for dissemination without all of the industry-specific details. Collaboration between industry and academia for publication may be a particularly useful way of informing technically high quality academic research with an applied framework and a more holistic industry perspective. Without impinging on industry confidentiality agreements, the research may be seen as more broadly applicable, with readier acceptance to more academically-oriented and higher citation index journals. However, this may mean that other industry groups may fail to recognise the solution to their specific problems that were found as a result of the work. Alternatively, the mine water literature is generally impoverished of case studies, particularly those with the technical rigour to be found in academic journals; thus, case studies may be of considerable interest to journals, such as this one, that serve a mixed audience of researchers and applied problem solvers.

A 'knowledge broker' is also a potential solution, where academically-minded industry professionals can help foster successful collaborations between industry and academia.

These have largely grown from the industry rather than from the university sector, where 'engagement' is still a nebulous term to describe any of the many tangible contributions academics may make to community and society. Use of external expertise in a 'broker'-type position can help universities understand what a specific industry and the university and its academics need from such a partnership to be mutually beneficial. Universities cannot expect the relationship to be wholly 'business as usual', as it would be with funding from competitive academic grants. Professionally-affiliated industry mine water consultants may help in this regard. Although formal research qualifications and experience is required, their knowledge of industry technical issues, solutions, and precedents can be an invaluable link between the industry and researchers. Consultants may also offer broader services that may improve the value of the academic research. These can include improved research project scope and research approach from the funding planning phases through peer-review of the final research deliverables, which is already an internal research-funding requirement of some large multinational mining companies. Equally, industry-funded research programmes may also benefit from similar oversight by industry technical experts.

Many research questions and opportunities have been and will continue to present themselves in the mine water field. How industry and academia collaboratively approach these opportunities will determine the future of both parties' internal goals as well as the broader industry's ability to predict and manage mine water issues in the future.

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