Untangling skills and qualifications: training engineers and related professionals capable of filling skill gaps in the mining industry

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Abstract*: In the current skill shortage it is necessary to reconsider the way engineering qualifications relate to specific engineering skills. This is especially the case in the mining industry where candidates with specialist qualifications are becoming harder to find. Qualification titles are commonly assumed to encompass a known and exclusive set of skills. However, key skills can overlap with those developed in other disciplines. Building on the skills of disciplines beyond the traditional sources of mining industry professionals requires a deliberate training and deployment strategy. In addition to technical skills, generic skills such as the capacity for life-long learning become particularly important when employers require substantial new learning as part of a graduate or junior level appointment.*

Introduction

Only a decade ago some commentators saw employment in the mining industry as being in decline:

> The outlook for employment [in the mining industry] is clouded by continuing uncertainty in Australia's main Asian markets and by the longer-term impact of environmental concerns. … Overall downward movement in employment is expected. (Dumbrell, 1998)

In stark contrast:

> Over the last decade the Australian minerals industry has experienced a significant shortage of minerals specialist graduates especially mining engineers and metallurgical engineers. Over the next 10 years, a predicted 7,659 additional professionals will be required by the minerals sector in Australia. This poses a challenge to all stakeholders associated with the professions in the minerals sector, particularly in regard to the attraction and retention of students in mining engineering and science programs at tertiary level. (MCA, 2006)

Perhaps not surprisingly, education and training has been unable to meet the industry's increased demand for engineering professionals. In fact, educational institutions and the business cycle seem to be so out of phase that specialized geoscience and mining engineering programs continue to be closed (Cas, 2007). Inevitably, the mining industry is faced with appointing personnel with qualifications and experience which does not match the template of qualifications and experience considered ideal for the job (MCA, 2006).

This paper addresses the significance this situation has for the way engineers need to be educated. Not just in terms of the skills taught but more significantly for the broader attributes of graduates.

Human Resources Perspective

Human resources professionals have typically been seeking candidates who hold an industry-specific qualification and have industry-specific experience.

> In practice, employers usually seek persons with mining industry experience. This applies across the spectrum of professional, trade and semi-skilled areas and thus makes the task of filling vacancies particularly difficult (Birrell et al., 2006).

However, these candidates are becoming rare as fewer graduates are being training in mining-related programs and more senior professionals rely more on their personal networks when changing jobs. Increasingly, candidates who hold qualifications not specific to the industry and have experience outside the industry are considered for mining industry roles. The proviso being that the employer must be confident that the candidate can develop the industry-specific skill set within an acceptable period. The candidate must demonstrate a high degree of motivation and willingness to learn new skills, but motivation is not sufficient in itself to make this transition possible. First, the qualification and experience has to be assessed as providing a relevant platform from which to build. Second, the organization must have a system in place to ensure the candidate receives appropriate training and mentoring to achieve the transition.

For the mining industry this scenario is commonplace as people with mining industry-specific qualifications and experience are rarely looking for work outside their personal networks and numbers of graduates have shrunk as universities have closed many undergraduate programs in related fields.

Deployment Strategies

For a company, the initial decision is on how to deploy a person whose qualifications and experience may be outside of the typical industry expectation.

Avoidance Deployment

This type of deployment involves identifying roles where a required skill is not relied on for useful work. In practice, this form of deployment may occur through intentional management or through the employee avoiding tasks reliant on weak areas. Such a deployment implicitly creates a sub-classification of para-mining engineer or para-geotechnical engineer who has no defined pathway toward gaining full accreditation in the core areas.

Developmental Deployment

This type of deployment involves identifying roles where a required skill can be acquired with appropriate support. The employee and their co-workers must be aware that acquiring the required skill is one of the goals of this deployment.

The initial deployment is likely to build on existing strengths of the employee so that they can contribute to the organization. If the employee becomes isolated from the activities of staff with the model qualifications/experience skill acquisition is unlikely to occur and the employee is effectively in an avoidance deployment.

In a study of engineers learning at work (Collin, 2002) the issue was summarized as:

> …the purpose and direction of learning at work are largely derived from the goals set of the work itself, arising naturally out of the demands and challenges of the job and out of social interactions in the workplace with colleagues and clients. Learning at work sometimes involves undertaking formal training, but almost always requires learning from experience and from other people.

Intentional mentoring or coaching support within the organization would be an integral part of achieving such development.

Defining skill sets

Industry bodies play an important role in codifying the skills assumed to be held by people with particular qualifications. In the mining industry the Australasian Institute of Mining and Metallurgy

(AusIMM) takes a lead role. The following roles are taken from summary career advice information prepared by the AusIMM (2006).

Mining Engineer

- Conduct investigations of mineral deposits and undertake evaluations in collaboration with geologists, other earth scientists and economists to determine whether the mineral deposits can be mined profitably.
- Prepare plans for mines, including tunnels and shafts for underground operations, and pits and haulage roads for open-cut operations, using computer-aided design packages.
- Prepare the layout of the mine development and the way the minerals are to be mined.
- Plan and coordinate the employment of mining staff and equipment with regard to efficiency, safety and environmental conditions.
- Consult with geologists and other engineers about the design, selection and provision of machines, facilities and systems for mining, as well as infrastructure such as access roads, water and power supplies.
- Operate computers to assist with calculations, prepare estimates on the cost of the operation and control expenditure when mines come into production.
- Oversee the construction of the mine and the installation of plant and equipment.
- Make sure that mining regulations are observed, including the proper use and care of explosives, and the correct ventilation to allow the removal of dust and gases.
- Conduct research aimed at improving efficiency and safety in mines.
- Establish first aid and emergency services facilities at the mines.

Geotechnical/Geological Engineer

- Investigate the engineering feasibility of planned new developments involving soil, rock and groundwater.
- Plan and undertake site investigations for proposed major engineering works such as bridges, dams and tunnels.
- Design measures to correct land contamination and salination.
- Design major structures in rock such as tunnels, basements and shafts.
- Supervise construction and performance of major engineering works involving the ground.
- Work out strategies to control landslides and areas of potential instability.
- Act as consultants or researchers act in managerial positions and be responsible for coordination of multi-disciplinary study teams, staff recruitment and matters of work organisation.
- Perform computer analyses, use computer databases and generate computer-aided designs.

People employed for mining engineering or geotechnical/geological engineering roles cannot be expected to have all these skills if their qualification and experience has not been aligned to these job roles.

Identifying skill gaps

For particular qualification or fields of experience it is possible to anticipate the main areas of skill gaps. Table 1 shows three examples of specific skills that may be expected between particular qualification and qualification commonly required in the mining industry.

Table 1. Examples of deployments where skill gaps exist.

Qualification/ experience with skill gap	Skill gap (examples)	Avoidance Deployment	Development Deployment	Template qualification/ experience
Surveyor	Calculate ventilation requirement	Resource and waste calculation tasks only	Calculate excavation volumes to contribute to ventilation calculations	Mining engineer

Civil Engineer	Calculate ventilation requirement	Excavation design tasks only	Assess exhaust and dust loads from planned excavation methods to contribute to ventilation calculations	Mining engineer
Geologist	Calculate excavation design parameters	Logging of rock mass defects only	Logging and use spreadsheets to calculate standard design parameters	Geotechnical/Geological engineer

An example skill gap: core logging

The ability to obtain data on engineering design parameters from cores of rock drilled into the site of a proposed excavation is an important skill for graduate level engineers. This activity has a number of characteristics:

- Conducted at remote sites
- Conducted with minimal supervision available
- Involves close interaction with drilling crews which are typically on contract
- Involves varying degrees of standardization between organizations/practitioners, some subjective judgement is required

Difficulties for university training include:

- Experience of academic staff in this work is often limited
- Holding appropriate core tray samples requires space
- Core samples need to be regularly replaced as they degrade with handling

For all these reasons core logging is a skill unlikely to be developed at university in all but the most specialized programs. It is a skill which has plenty of opportunity for practice as a junior engineer may be required to participate in the logging of kilometres of rock core in a given project. The most problematic phase is providing opportunities for graduates to develop basic skills that will enable them to commence working on core logging tasks with minimal supervision. RMIT and Coffey Mining have collaborated to produce a practice-based manual and test core (on loan from the Victorian DPI core library) for introductory skills development.

The Consulting Engineer

In the Australian mining industry it is not uncommon for graduates to commence as junior staff in consultancies. The consulting environment provides some special challenges for on-the-job training. Smid (2001) identified workplace learning issues related to consultants as:

- "Get in touch with the client system, build a relationship with that system, make a contract (legal, financial and psychological) and a proposition, define their own role and the role of their fellow practitioners, support colleagues, and manage the relationship with the client in the long term *(relation between systems)*;
- Make a methodical diagnosis, making inferences, trying to develop an analysis and preparing an interpretation or judgement of the processes in the other system, not for the sake of the analysis itself, but with an eye to intervention and turning it into a tool or "product" *(diagnosis);*
- Plan and implement a strategy or an intervention in the other system at individual, group or organisational level and turn it into a "product" *(strategy and intervention);*
- Reflect, maintain their own learning capacity, monitor their own development and provide assurance that they work according to the state of the art *(learning and development and professional quality)*."

These professional skills are an important part of the consulting engineer's work and are not explicitly related to any particular qualification. These are generic skills that can be developed in a wide range of university programs to give students the best possible opportunity to succeed in a consulting engineering organization.

Implications for university training of engineers

Tertiary education institutions can be involved in professional development programs and training for specific capabilities in the workplace. However, in this paper the focus is on the role of tertiary education in preparing graduates to be adaptable to roles in a wide range of industry sectors. It is essential that engineering and allied education emphasizes that acquiring knowledge in one field can be used as a model for acquiring knowledge in a new field.

The educational process involves:

- Interaction with a person familiar with the knowledge and skills required to be competent in a given field.
- Introduction to the key sources of information covering that field.
- Awareness of the location of other sources of information on specific topics in the field.
- Interaction with peers.
- Opportunities to practice skills with appropriate guidance and feedback.
- Assessment of capabilities by a person familiar with the knowledge and skills required to be competent in a given field.

This learning process is analogous to the support likely to be available in the workplace (Table 2). Students should be encouraged to view their successful negotiation through this cycle in their various courses as preparation to complete the learning cycle in their workplace with a new set of learning objectives.

Table 2: Comparison of learning in an educational institution and in the workplace

	Educational institution	**Workplace**
1. Guidance	Teacher	Senior colleague (mentor)
2. Primary resources	Text/readings	Manuals
3. Other resources	e.g. Library resources	e.g. Previous reports
4. Interaction	Fellow students	Colleagues
5. Practice	Assignments	Project tasks
6. Assessment	Grading	Review

One method of demonstrating that readiness to learn is an essential skill for employability is to integrate tertiary education with workplace practices, sometimes referred to a work-integrated learning. A definition of Work Integrated Learning (generalized from RMIT policy) is

> educational activity that combines and integrates learning and its workplace application, regardless of whether this integration occurs in industry or in the university and whether the activity is real or simulated. It is the umbrella term used to describe all educational activities that combine and integrate learning and its workplace application as part of a program of study. These activities should demonstrate the same qualities as good curriculum design including: an alignment of clear goals for learning, support to achieve them, feedback on progress, assessment of achievement, and clear expectations of the roles of the parties.

The mining industry, in particular, will benefit from tertiary education which prepares graduates to embrace the challenge of learning new skills in an environment of “learning-integrated work”.

Conclusions

One response to skills shortage is to select personnel who demonstrate the greatest capability to develop the skills required. Success in closing the gap between existing skills and the skills required involves three factors:

- Having the minimum gap in skills between the existing qualification and experience and the model qualification and experience.
- Selecting personnel with the personal attributes needed to acquire the required skills.
- Having a system of personnel deployment that utilizing existing capabilities while providing structured opportunities to acquire the required skills.

University training can have a determining influence on the second of the factors above. Educators must avoid explicitly or implicitly promoting the notion that the specific technical skills developed during degree training are the only skills an employer may require of them.

Clearly, there will be innate personality traits which lead one candidate to express a high level of confidence in their ability to acquire new skills. It can also be expected that this tendency is also affected by prior experiences in acquiring new skills. Since university education is the prime learning experience for engineering and related professions it can be anticipated that students' experience of acquiring new skills during their university training will be a major determinant on their level of confidence in this area.

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