# Enhancing students' engagement in learning through field based approach: A case study from a mining engineering course

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## CONTEXT
It has been well established that learning in the field differs along multiple dimensions from learning inside a classroom. While classroom-based learning is focused on theory, field-based learning inquiry often relies on methodical observations and brings students into direct experiential contact with mining practises.

## PURPOSE
This paper presents a case study of the influence that field-based teaching has on students' learning and engagement in three units in the mining engineering program at Monash University since its inception in 2013. An important is posed: How can we assess the impacts of field experiences on student learning and attitudes about mining engineering?

## APPROACH
The field-based teaching method was adopted in three units taught by the first author, i.e., Introduction to mining (ME1010), Surface mining systems (MNE3040) and Drilling and blasting (MNE3060). The student evaluation reports are used to demonstrate the significance that field trips have had on students' learning outcomes. While there was no 'structured student survey' undertaken to measure the impact of the field trips on students learning, the level of student engagement and participation in the classes and tutorial activities were used to assess any changes in student learning outcomes.

## RESULTS
The Students Evaluation of Teaching Units (SETU) open-ended questions at the end of the unit evaluation questionnaires suggests that strong student engagement and learning outcomes were achieved by exposing the students to the field and it also aided students' learning.

## CONCLUSIONS
A field-based approach was successfully developed and implemented in the first and third year mining engineering units. The level of student endearment and participation along with the end of semester SETU comments suggest that field contributed to rich learning experiences for students.



## KEYWORDS
Field-based learning, student engagement, mining engineering and case study.

# Introduction

The Australian mining industry is being challenged by several issues, such as higher costs of doing business, falling commodity prices and ore grades, increasing energy costs and lack of trained and competent professional engineers to run the business. To help the mining industry to meet its growing demand for competent professional engineers, Monash University established an undergraduate mining engineering degree program, namely, the Bachelor of Mining Engineering (Honours). This degree program was developed around the theme of '*mining of the future*', incorporating automation, safety, economics, project management and teamwork, sustainability, people and community, communication skills, innovation and leadership producing profitable projects with a minimal environmental footprint.

There are various teaching-learning approaches to enhance student engagement and enhance their learning experience. This paper examines a case study of a successful field-based teaching-learning approach to aid students' understanding of the subject while enhancing their engagement. The classroom-based learning is focused on the theory; the field-based learning inquiry often relies on methodical observations and brings students into direct experiential contact with the mining practices (Karmis, Hebblewhite, Ruiter, Scoble, Cedron, Phillips, 2010). Approaches such as hands-on, field-based and practice-based learning/teaching help facilitating students to foresee and react effectively to the uncertainties of changing the technological, social, political and economic world (Patil, Mann, Howard and Martin, 2009, Reed and Poppel, 2003).

This paper outlines methodology and effectiveness of field-based learning approach for undergraduate mining engineering course at Monash University Australia. The paper further reflects on the qualitative feedback of student participants about their positive learning experience using field-based study.

# Mining Engineering at Monash University

Australia is endowed with diverse and abundant mineral resources and its economies rely heavily on their mineral production and exports. In 2015, the mining sector contributed around 8.7% to Australia's GDP, employed ~ 2% of the workforce[1]. Mining has been one of the driving forces for much of the exploration of Australia's remote inland and for Australia's industrial development (Hajkowicz, Heyenga, and Moffat, 2011). One of the biggest challenges facing the industry in Australia, as in other parts of the world, is the continued availability of skilled human resources, in particular, professional mining engineers.

Responding to this need, Monash University has established a Bachelor of Mining Engineering degree program in 2013 with a view to increasing Australia's supply of mining engineers - addressing the significant international and domestic need. The new degree program is developed to produce a new type of mining engineer for the future with strong technical competency backed by good "soft skills" such as interpersonal, communication and people skills. The first intake occurred in 2013, resulting in the commencement of 24 first-year students and eight higher level students, who using advanced standing provisions, articulated into the second or third-year levels from the Civil Engineering program.

The mining program has been heavily endorsed by the mining industry, which is evidenced through their comprehensive input to the educational design and generous financial support which has underpinned the establishment of dedicated laboratory facilities and the appointment of key specialist staff. Newcrest Limited and MMG Limited have been the founding financial contributors to, and enthusiastic supporters of, this new program. Monash's mining program received provisional accreditation in 2013 by Engineers Australia.

[1]Australian Bureau of Statistics cat. no. 5204.0, Table 5.

In 2013, being a brand new program, Monash could not join the well-established 'Mining Education Australia (MEA)' consortium. MEA is an internationally unique industry-academic collaboration to deliver an economically sustainable and academically excellent mining engineering curriculum to support an industry that underpins Australia's economy and is fostered and financially supported by the Minerals Council of Australia via its educational arm, the Minerals Tertiary Education Council (MEA, 2014). This necessitated Monash developing its own, independent curriculum, which in many ways helped Monash – especially to diversify into Oil and Gas, Geological and Renewable Energy engineering areas. While the curriculum was built around the MEA model, it was customised in line with the unique emphasis set out in the program objectives.

# Field Visits to Enhance Students' Learning Experience

Mining engineering is unique in that it requires special considerations in curriculum design and close interaction with the industry (Karmis, Hebblewhite, Ruiter, Scoble, Cedron, Phillips, 2010). The main goal of engineering education is to provide the knowledge, attitudes and level of understanding to produce graduates who are well prepared to enter a professional career upon completion of their degree (Male and King, 2013 and Birand, 2006). It has been well established that the learning in the field differs along multiple dimensions from classroom learning (Oosterloo, 2005). Most research on school-based learning has focused on learning that occurs in a classroom, laboratory, library or computer room (Knapp, Greer, Connors, and Harbor, 2006), but in mining, civil and environmental engineering and environmental and geosciences (Manduca and Carpenter, 2006) the field-based learning is vital to give students a right perspective of scale of operations.

So far, the research on field-based learning has been in the form of educational evaluation of specific field-based programs either in earth (Orion, Ben-Chaim Chaim, and Kali, 1997) or ecological and environmental sciences (Latour, 1986). Hemler and Repine (2006) used pre and post instruments, group interviews and constructed response items to investigate the development of skills, understandings, and attitudes across a three-week field geology course for in-service teachers. They documented what techniques and concepts the participants reported as most difficult (*e.g.*, measuring dip and strike), and the participant's growing understanding of a geological map as an interpretive construct (SERC, 2016).

A wide variety of teaching-learning approaches have been adopted to enhance student learning and engagement in mining engineering programs. These include: (a) face-to-face presentations by the first author and mining industry experts, (b) field-based learning through field trips to mines in Victoria, Tasmania and New South Wales, and (c) industry-based projects and group activities. The field-based learning in mining engineering includes going to mine sites, making observations of processes and phenomena and taking notes, collecting samples of rocks and soils using the human senses and at times though portable field instruments. Generally, the features of interest include rock formations, dips, strikes, joints, slope designs, benches, roof and floor rocks, subsidence, bodies of water, the interrelations among these, and the processes by which they change through time or vary across space, either naturally or due to anthropogenic influences.

It was with this view; a number of field trips to mine sites and quarries were undertaken to give the students first-hand knowledge of the practice in various units, i.e., Introduction to mining (ME1010), Surface mining systems (MNE3040) and Drilling and blasting (MNE3060). The field trips were undertaken to mines and quarries in Victoria, New South Wales and Tasmania to provide the students with direct exposure to the practical applications of theoretical concepts and aid students' understanding of the theory.

Table 1 provides an overview of the various field trips organised for the students in the various units taught by the first author in past4 years. For example, the field trips organised as part of MNE1010 in 2013 and 2014 to Cadia mine in NSW (via Newcrest donor in 2013) and Roseberry mine in Tasmania (via MMG donor) were meant to give the students understanding in semester 1 of their first year of ‘what being a mining engineer is all about’. This also helped the students to correlate the theory with practice. The group of students were divided into small teams of 3-4 students, led by a group leader, for logistics purposes. It was the group leaders’ responsibility to ensure that the tasks assigned to each group (prior and post tour) were undertaken adequately. It was also expected that each group has a better coordination in collecting the data and information for the preparation of a report on return.

**Table 1 Field trips conducted in various mining units taught at Monash University**

| Unit | 2013 | | 2014 | | 2015 | | 2016 | |
|---|---|---|---|---|---|---|---|---|
| | Place of visit | No of students | Place of visit | No of students | Place of visit | No of students | Place of visit | No of students |
| **MNE 1010** | CVO & BBC (NSW) | 35 | RM & SRM (TAS) | 26 | SCM & CDM | 55 | SCM | 44 |
| **MNE 3040** | HWM & LVBQ (VIC) | 5 | HOJQ (VIC) | 11 | | | | |
| **MNE 3060** | HOJQ (VIC) | 8 | HOJQ (VIC) | 16 | HOJQ (VIC) | 15 | HOJQ (VIC) | ~7 |

CVO-Cadia Valley Operations (Newcrest Ltd); BBC-Baal Bone Colliery (Xstrata Coal); HWM-Hazelwood Mine (GDF SUEZ Energy); LVBQ-LV Blue Metal Quarry; HOJQ-Holcim Oaklands Junction Quarry; RM-Rosebery Mine (MMG Limited); SRM-Savage River Mine (Grange Resources); SCM-State Coal Mine (Wonthaggi); CDM-Central Deborah Gold Mine (Bendigo)

## *a) Activities during field visits*

The purpose of the field trips were to provide students (in MNE1010, MNE3040 and MNE3060) with direct exposure to the practical applications and to bring clarity to the classroom teaching-learning and provide a more practical view of some of the theoretical outcomes of the respective units and also provide students with a holistic view of both surface and underground mining operations. The learning outcomes from a class room environment are always much more significant when they can be tied directly to the practical applications through mine visits. It was also intended that the early exposure of students to mines will assist them in their understanding in subsequent units. Students were engaged in several teaching and learning activities during their field visits such as collecting data, performing design calculations, estimating volumes and preparation of a report. Figure 1 gives some of the snapshots of such activities undertaken in the field setting.

The main objectives of the field trip are to develop students’ appreciation of:

- the skills and challenges associated with the mining discipline and mining operations.
- the range of characteristics and composition of mineral deposits.
- a range of methods for mining both coal and metalliferous deposits.
- the importance of ground control in open pit and underground mining operations.
- the typical work cycle of mining operations.
- mechanisation in both surface and underground mining settings.
- the range of typical mine site activities

At the conclusion of the tour, the students had an understanding of the practical relevance of a range of mining methods adopted for extraction of individual mineral deposit and also have an appreciation of key aspects of how open-cut and underground mining is conducted.

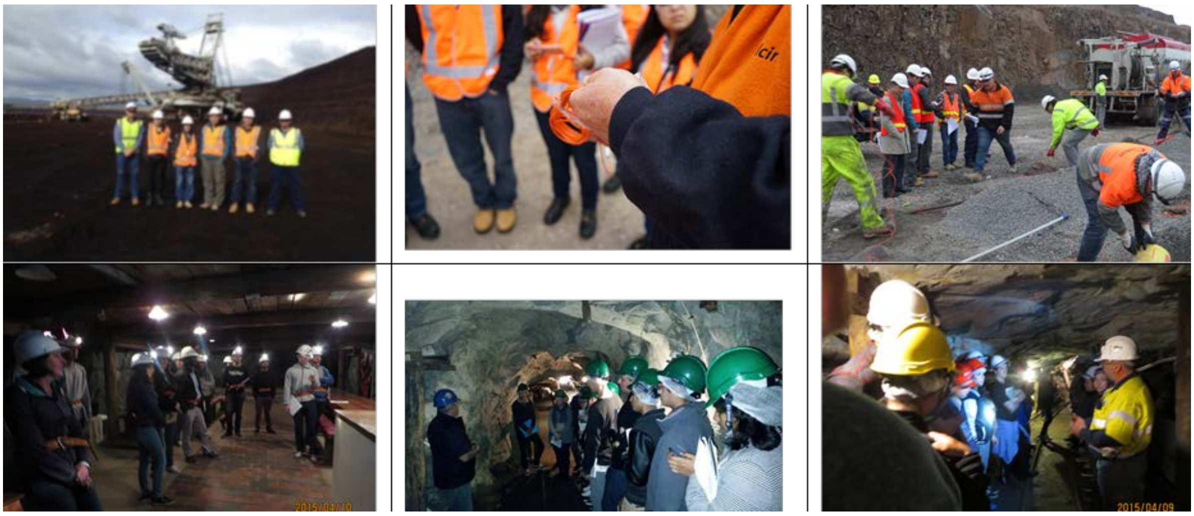

**Figure 1 Snap shots of field-based learning through field visits to mines**

## b) Assessment during field visits

To make sure that the objectives of the field trips are achieved, an assessable report based assessment was included at the end of the field trip, typically worth a significant part of continuous assessment component for the unit (10-20%). This assessment component helped students to connect theory with practice and also ensured that the students are observant while on the trip.

Students were required to maintain a 'Daily Diary' to record their daily activities and the same had to be attached as an annexure to their report. The students were required to collect the necessary data and information and prepare a detailed report (individual) within two weeks of completion of the field trip. The report must adhere to the 'field trip report guidelines' supplied to students a week before the actual field trip which was required to contain information in Box 1 and submitted for evaluation.

**BOX 1**

**Essential Contents of Report**

The report should at least cover the following aspects of each operation that you visit and be structured as follows:

Introduction: Name of the mine along with names of owner, agent, manager and other senior officials.

Location and a brief history of the mine (include a location map).

Management structure (include the organisational chart)

A summary of production physicals – commodity produced, tonnes mined and processed, saleable product produced

Where/how the product is sold

**Other sections included the following themes:**

Brief geological description along with characteristics of the ore and its marketing scenario.

A commentary on reserves and resources may also be provided

Brief description of surface infrastructure including offices, workshops, ore processing facilities, waste rock and tailings management facilities, surface ore stockpiles, water storages, other significant infrastructure

Approach to high level production planning and scheduling

| |
|---|
| Sampling, and grade control, survey, training and mines rescue stations |
| Innovative/state of the art approaches to mining and processing |
| Environmental management and reporting |
| Community relations |
| Key observations and conclusions |
| Acknowledgements |
| References |

At the conclusion of each of the field trip, the students had a better appreciation of quarrying/mining settings for extraction of minerals and also have an understanding of key aspects of how a quarry/mine is operated on a day-to-day basis. A high priority was accorded to providing students with constructive, succinct and timely feedback on assignment submissions. An approach has been developed which uses a template feedback sheet (see Figure 2), which highlights both strengths and weaknesses in student submissions. This type of format provided space for tailored comments but reduced marking time and improved marking consistency.

| Component | Details | Value | Achieved | Comments |
|---|---|---|---|---|
| Cover page & ToC | Neatness, design, title, names, table of contents, etc.<br>Cover page attached and signed | 2.5 | 0 | • No Cover Page(-1.5)<br>• No Table of Contents(-1) |
| Introduction | Succinctness, clarity, numbering, comprehensiveness | 5 | 3 | • Ownership is mentioned.<br>• Location is mentioned, but map is not clear.(-0.5)<br>• Organisational structure is not applicable for this mine. Figure given is also not very legible. (-1)<br>• Production history is mentioned but not completely. (-0.5) |
| Statement of Aims & Objectives | Succinctness, clarity, comprehensiveness | 2.5 | 1.5 | • Aim is mentioned (but not clearly)(-0.5)<br>• Objectives are vaguely mentioned (-0.5) |
| Discussion addressing the 'Essential Contents of Report' | Supporting evidence by appropriately referencing, lateral thinking, heading numbers (for tables on the top and for figures at the bottom), Only compulsory figures/diagrams and tables and their cross referee within the body of the text and vice-versa | 60 | 41 | • No sections and headings mentioned anywhere in whole report. (-3)<br>• Text looks copy pasted (random numbers that are not referenced appear throughout text ). No Plagiarism please. (-5)<br>• Geology of mining area is not clearly mentioned. (-3)<br>• Surface features are mentioned.<br>• Understanding of usage of surface features not well understood (and wrong) (-2)<br>• No Referencing is done anywhere. (-3)<br>• The mining method used for specific mine is not mentioned properly. (-3) |
| Conclusions | Clear statement of the achievements & observations stood up of the fieldtrip | 7 | 5 | • Conclusion needs serious rephrasing as many sentences do not make sense. (-2) |
| Acknowledgements + References | Whether followed scientific referencing style (Standard approaches must be used)<br>All references in the body of the report are in the reference list at the end of the report<br>The Author-date reference system is the standard approach for engineering reports. | 3+7 | 0 | • No Acknowledgement<br>• No References |
| Formal issues of the report + Appendix | Grammar and expression checked (Proof read your report and use the grammar checking tools in your word processor)<br>All figures are numbered and have captions. Figure captions are below figures.<br>All tables are numbered and have captions. Table captions are above tables.<br>Headings numbered consecutively<br>Pages numbered<br>Appendices have the same standard of expression, spelling and grammar as the main report<br>Superscripts and subscripts are used as appropriate e.g. m3 not m3 or m^3<br>Numbers have appropriate significant figures with a comma separating thousands e.g. 34,000 | 7 + 6 | 0+6 | • No figure captions and headings throughout the text. (-1.5)<br>• Some figures are illegible and irrelevant.(-1.5)<br>• Some figures are not properly formatted to fit the report. (Randomly placed). Formatting of text is also not proper. (-1.5)<br>• No Page Numbers(-1.5)<br>• Grammar and expression check is not done. (-1)<br>• Attached field Notes |
| | | 100 | 60 | |

**Figure 2 Assessment rubric developed to give tailored feedback to students on the fieldtrip reports**

## *c) Student experience of field visits*

Our observation of students' engagement and level of participation in both lectures and tutorial sessions strongly indicate that the direct experience of an active mine or a quarry site have been found to aid and influence the students' understanding of theory. The students who had visited a mine or quarry site reported the greatest knowledge of mining activities upon returning from a field trip and got involved with subjects compared before undertaking the field tips. Furthermore, the significant interaction between mine site visits demonstrated a similar trend in knowledge held by the students, which is what observed through the quizzes that were conducted at the conclusion of the field tips.

While there was no ‘structured student survey’ undertaken’ to measure the impact of the field trips on students’ learning, it was experienced by the authors that the student engagement has significantly increased after the field trips were undertaken. The field-based teaching-learning model not only achieved student engagement and active participation in the classes and tutorial activities but higher success rate in the unit, which has been outlined with passing and retention rate as illustrated in Table 2. This strongly supports the argument that field–based teaching contributes to Enhanced students' engagement in learning.

Based on the observations, the authors suggest that direct experience with mining from a field visit substantially affects the amount of knowledge related to mining activities. These observations strongly resonate with similar observations made by Hope (2009). While Boyle, Maguire, Martin, Milsom, Nash, Rawlison, Turner, Wurthman and Conchie (2007) considered field visits as a deeper form of learning, Foskett (1999) suggested a significant relationship between direct experiences and enhanced cognitive and effective gain and demonstrated that direct experience makes understanding more enjoyable and effective.

**Table 2 Field trips conducted in various mining units taught at Monash University**

| Grades | MNE1010 | | | | MNE3040 | | MNE3060 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2016 | 2013 | 2014 | 2013 | 2014 | 2015 | 2016 |
| | % Stud | % Stud | % Stud | % Stud | % Stud | % Stud | % Stud | % Stud | % Stud | % Stud |
| High Distinction | 27 | 13 | 16 | 30 | 50 | 33 | 20 | 47 | 20 | 16 |
| Distinction | 52 | 35 | 18 | 39 | 50 | 33 | 40 | 7 | 40 | 67 |
| Credit | 21 | 30 | 35 | 23 | 0 | 34 | 40 | 27 | 40 | 17 |
| Pass | 0 | 3 | 20 | 2 | 0 | 0 | 0 | 7 | 0 | 0 |
| Fail | 0 | 0 | 9 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Absent | 0 | 19 | 2 | 4 | 0 | 0 | 0 | 12 | 0 | 0 |

The students have highly regarded the importance of field trips undertaken, which is reflected in their open-ended responses below from the unit evaluation questionnaire (see Box 2). Overall, there was a positive response and strong student support for the implementation of the field-based teaching model in the mining engineering units (MNE1010, 3040 and 3060).

**Box 2**

**SETU Qualitative Feedback**

- *The excursion was also very well executed, and was one of the best learning experiences of the subject (MNE1010, 2015).*
- *The field trip gave students an idea of what they should expect once start working (MNE1010, 2015).*
- *The field trip was an excellent opportunity to apply the learnt material to the physical world. It was invaluable to my learning (MNE3060, 2014).*
- *The field trip was highly informative, and taught me more about the course work (MNE3060, 2014).*
- *The field trip was the best aspect as it allowed us to see the drilling and blasting operations in person (MNE3060, 2014).*
- *Field trip greatly improved my understanding of topics covered (MNE1010, 2013).*

- *Field trip was highly enjoyable, as well as helping us understand how a mine operates (MNE1010, 2013).*
- *The field trip to NSW was the best aspect since it gave you an idea of how a mining operation runs (MNE1010, 2013).*
- *The field trip was the best learning experience doing this unit. (MNE1010, 2013).*
- *I have learnt a lot practical theory from a field trip (MNE3060, 2013).*
- *The field trip was quite enlightening (MNE3060, 2013).*

# Conclusion

This paper has presented a case study of a mining engineering course at Monash University on how field based approach has contributed to enhancing students' engagement in learning. A field-based instruction approach was successfully adopted and implemented in many units of mining engineering program at Monash University, with some project-based components increasing in extent, complexity and student autonomy in later years of the program. This appears to be the best way to satisfy industry needs, without sacrificing knowledge of engineering fundamentals. It has also been demonstrated that the engineering profession and academics are more familiar with the concepts of projects in their professional practice, than with the concepts of problem-based learning.

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