Beyond the traditional lecture: mining engineering education using multiple intelligences

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Abstract

The concept of intelligence has evolved from the traditional idea of IQ to emotional intelligence (EQ) which considers not only one's capability to solve logic problems, but also the ability to manage emotions. In addition to these two well-known intelligences, Gardner (2003) presents other intelligences that are particularly relevant to education. Today, educators are faced with the challenge of imparting a variety of intelligences to their students in order to adequately prepare them for working in the today's complex world. An instructor's choice in curriculum, personal style and approach to lectures can have a major impact on the student's multiple intelligences. Engineering students are often taught in a very traditional manner with rigid course content focusing on the technical and mathematical skills required for success in the profession. However, what is often lacking in engineering education is an understanding of technology's impact on society, concepts of sustainability, corporate social responsibility, etc. At the University of British Columbia, one instructor is using non-traditional methods including parodies and skits to engage students while increasing their level of all intelligences. In the Mining and Environment course, the instructor uses musical parodies to explain the impact of engineering projects on the environment and society. Songs such as "Why ARD?", "Reclaim", "How Deep Is Your Mine", and "Acid Rain". A survey of the class shows that the music is an effective learning tool for engaging students and has led to a greater awareness of sustainable development and social responsibility and their role as engineers. The success of this musical teaching method, suggests that a similar, non-traditional approach by other instructors could help provide students with a higher level of 'other intelligences'.

Introduction

For centuries education has been discussed, studied and considered a vital building-block in society. Content (the "what") and structure (the "how") are the main themes of focus for pedagogic professionals. While some changes in the "how" students are taught have taken place the predominant model still involves lectures in which students sit passively, as an empty container waiting to be filled up by the lecturer's knowledge (Freire, 2000). In fact, the traditional lecture format reaches very few students effectively, because only 12 to 18% of the population learn orally (Russell Martin & Associates, 2009).

Another important aspect that impaired a more holistic approach of education is related to the understanding of what intelligence is and the methodologies adopted to measure it. The idea of a single general intelligence and a focus on the logico-mathematic dimensions led to people being labelled. Educators taught their students as if only one way was available; this has been the experience in the majority of Science departments. In Applied Sciences the nature of the content emphasizes the logico-mathematical approach which is indeed important; nevertheless just because the content is technical, does not require that it be taught in a rigid manner.

The second half of the 20th Century was particularly important for the psychology and education fields. Discussion and debates began about a broader view of intelligence and new ideas emerged from theorists such as Howard Gardner. Gardner (1993), the father of the Multiple Intelligences Theory (MI) states that humans rather than possessing a single intelligence possess a number of relatively independent intelligences. This paper discusses the results of a survey distributed among engineering students in order to understand their perceptions in relation to a specific class in which the instructor adopts un-conventional teaching methods. The course being discussed is Mining and the Environment (MINE 391) where the instructor uses unique methods including music and skits. The study seeks to

understand if students perceive this as an effective approach that aids in their understanding of the course content. Accordingly, the paper is structured as follows: a discussion of Engineering the Engineering Education; an overview of MINE 391, an analysis of survey results followed by conclusions and final remarks.

Engineering the Engineering Education

Mining engineers have traditionally been focused on the extraction, production and processing of mineral resources. In today's world, mining engineers must also be concerned with the mitigation of environmental and social impacts as a result of mining. This extra responsibility requires an additional educational component beyond the traditional training received in the past. The mission statement of the University of British Columbia (UBC) Mining engineering department reflects this added education requirement. The department's goals include: ensuring that students and faculty are grounded in the realities of the complex issues that confront mineral developments today, and to develop highly qualified people with effective and ethical leadership, teamwork, networking and interpersonal skills. (http://www.mining.ubc.ca/MissionStatement.html)

Mining engineering is presently involved in a paradigm shift towards planning for ecologically sound mining with environmental management. With this technical development has come an increasing interest in social responsibility and in development of ethical planning with mining communities for positive, long-term relationships. It is no longer acceptable for mining engineers to claim to not know that mines could cause disastrous environmental and unfortunate human consequences; they must be prepared to prevent such occurrences. In managing these difficult issues beyond the technical dimension requires Mining Engineers to draw on multiple intelligences.

Psychometricians believe that individuals are born with a single and general intelligence often called intelligence quotient (IQ). In the last century IQ defenders claimed that wealth and high IQ was inter-related underpinning that social class and IQ are directly related. In order to ascertain one's general intelligence specific tests such as ability to define words, select antonyms, remember passages and manipulate geometric shapes have been adopted extensively. This approach led to the assessment of humans as having a single intellectual capacity, which almost always amounts to an amalgam of linguistic and logical mathematical skills. This supports the idea that high intelligence relates to the ability to solve difficult logical problems in a quick manner.

However in the last few decades the traditional way of approaching intelligence has been challenged with a more broad view of intelligence being discussed. Howard Gardner defines intelligence as "the capacity to solve problems or to fashion products that are valued in one or more cultural setting" (Gardner and Hatch, 1989). Following the trend of seeing intelligence more broadly than the logico-mathematical intelligence and the verbal-linguistic intelligence, Gardner argues that human beings have several relatively autonomous mental faculties such as musical intelligence, spatial intelligence, and bodily kinesthetic intelligence (Gardner, 2001). Furthermore he has presented interpersonal and intrapersonal intelligences and later introduced the eighth intelligence called natural intelligence. Table 1 summarizes Gardner's intelligences.

Table 1: Multiple Intelligences, Source: Gardner, 1993.

Verbal-Linguistic Intelligence	**The intelligence of words –** Process information through language. Sensitivity to meaning, order, sound of words is noticed. There is a natural ability to explain, persuade and also enjoy listening to or reading stories.
Logico-Mathematical Intelligence	**The intelligence of numbers and reasoning -** Analyzing, grouping, categorizing, recognizing relationships, creating order out of chaos, reasoning, predicting, etc. are the main characteristics of this intelligence.
Musical Intelligence	**The intelligence of tone, rhythm, and timbre -** Features of this intelligence indicate that learning takes place through sound, rhythm and musical metaphor.
Visual/Spatial Intelligence	**The intelligence of pictures and images -** Distinct characteristics of this intelligence are a sense of direction, thinking and planning in three dimensions.
Body/Kinesthetic Intelligence	**The intelligence of the whole body and the hands -** The ability to use one's body to express an emotion, to play a game or to create a new product is an evidence of the cognitive features of body usage.
Interpersonal Intelligence	**The intelligence of social interactions -** a core capacity to notice distinction among others. In particular contrast in their moods and temperaments, motivations and intentions. This intelligence also permits a skilled adult to read the intentions and desires of others even when these have been hidden.
Intrapersonal Intelligence	**The intelligence of self-knowledge -** is the knowledge of the internal aspects of a person: access to one's own feeling, life, one's range of emotions, and the capacity to effect discriminations among these emotions and eventually to level.
Naturalist intelligence	**The intelligence of nature -** The core of the naturalist intelligence is the human ability to recognize plants, animals, and other parts of the natural environment, like clouds or rocks.

The theory of Multiple Intelligences (MI) opened up new horizons in teaching and learning processes that surpass the traditional word smart / mathematical smart methods (lecture, textbooks, writing assignments, formulas, etc.) adopted in most schools (Armstrong, 2000). After the 20 years since its introduction, MI is well accepted in education with ideas integrated into the work of many teachers. Several innovations were introduced as programs in schools; however most of them in the primary and secondary level of education. There are entire schools and whole curricula founded on Gardner's theory, for example the Howard Gardner School for Discovery in Scranton, PA, USA. These schools actively engage children and teach all subjects and all levels. The educational approach is experiential and students learn by doing; lessons are taught to a variety of learning styles to allow the participants to leverage their strengths while still developing areas which are not as strong.

Considering the limitation of teaching in a lecture style, and how intelligences of individuals vary, one can argue that having different teaching methods available for introducing concepts is worthwhile. Planning and executing a curriculum can provide alternative ways of delivering concepts, which in turn can enhance the ability of students to learn them. This reinforces the importance of integrating various pedagogical approaches to meet the needs of diverse learners (Belliveau, 2005). One of the major gaps in the concept of intelligence is emotional intelligence, a concept made popular by the groundbreaking book, Emotional Intelligence, by Daniel Goleman. For various reasons and thanks to a wide range of abilities, people with high emotional intelligence tend to be more successful in life than those with lower Emotional Intelligence (EQ) even if their classical IQ is average (Goleman, 1995).

EQ is defined as the ability of a person to perceive, assimilate, understand, and manage their own emotions and those of other's. This can be important in an organizational context where several perspectives need to be considered in a respectful manner. Professional mining engineers must be able to understand the technical factors, while upholding environmental and social ethics. Being able to motivate oneself and persist in the face of frustrations, control impulses and delay gratification, having empathy and hope are all examples of EQ. Controlling emotions and being able to keep distress from swaying ones ability to think is critical. The essence of this theory is that people become more empathetic towards others and therefore increasingly aware of how they are reacting to a given situation. Considering intelligence to be a skill implies that it can be taught and learned, and directly challenges the traditional concept. "I endorse the notion of emotional intelligence when it denotes the capacity to compute information about one's own or others' emotional life" (Gardner, 1993).

The Mining industry is active across all continents, and mining engineers often find themselves working abroad in remote communities and in many cases with Indigenous communities. Diverse cultural values can complicate busi-

ness practices and historically has led to miscommunication, conflicts and lost opportunities. Mining engineers are required to develop critical thinking skills, as well as decision making skills in order to provide professional leadership in their field. It is the role of education to prepare leaders who are capable of thinking critically about political, social and environmental considerations. A complicated political environment demands awareness that, securing real change in political or social conditions requires negotiation, dialogue, and multiple points of entry. By studying real cases students can learn to appreciate the practical problems as well as propose possible solutions. Mining sites are complicated in terms of technology, chemistry, and geography, therefore international and domestic politics, law, ethics and culture are all considered in possible approaches (Henry, 2006). The way to teach real learning is to engage deeply entrenched ideas through integration, application and discussion in order to encourage a maturing of the students own ideas (Gardner, 1995).

One form of education that is of critical importance in the development of humanity is that of music and the arts. Elliot Eisner (1998) states the significance of education as: "Encouraging a willingness to imagine possibilities that are not now, but which might become. A desire to explore ambiguity, to be willing to forestall premature closure in pursuing resolutions. The ability to recognize and accept the multiple perspectives and resolutions that work in the arts celebrate." (p. 14). He suggests that perhaps attitudes are developed that promote risk-taking, and hard work; as well as an enjoyment of learning that promotes more involvement and greater motivation in the process.

Engineering schools are well known for logical mathematical approaches and in order to be successful in this field one must have good mathematical skills. However what has been tested and argued is that working with the other types of intelligences can be a tool to enhance all learning. This allows students to be reached in a variety of ways and concepts in a topic can be captured not just through a single symbolic language but rather through a range of methods. Innovative methods have been adopted to teach mining engineering students at Norman B. Keevil Institute at the University of British Columbia.

Mining and the Environment (MINE 391)

Mining and the Environment (MINE 391) is an undergraduate course which focuses on the social and environmental issues of mining activities. Additionally, it teaches what must be done in order to avoid and mitigate these issues. Themes such as Reclamation and Mine-Closure, Acid Rock Drainage (ARD), and Acid Rain are part of the syllabus. The unique quality of this course is an innovative approach in teaching that has been adopted using well known musical hits presented in an interactive way. Each major course theme has been transformed into a specific parody performed and interpreted by the instructor every Wednesday in class. The initial reason for using songs as a teaching method was to engage students and reinforce the concepts being discussed in the class. This innovative and interactive approach to pedagogy is not meant to negate the traditional styles of teaching; rather it aims to promote alternative methods of connecting and stimulating the diversity of learners in the classroom (Belliveau, 2005). This concept is supported not only on pedagogical field but also in psychology. Rauscher, Shaw, and Ky (1993) found that musical experiences may enhance performance on spatial capacities (Gardner, 1993).

Mine-closure and reclamation planning are now recognized as basic requirements for mining companies proposing a project. This however was not always the case, in the past a lack of knowledge of the impacts from mining and irresponsibility on the part of the company, these stages were not considered by the mining company. Instead, mining companies exploited the area, extracted the recourses and left behind a legacy of environmental and social impacts for the next generations. The first song presented in the class stresses an example of how mine activity was performed in the past and the resulting consequences of these past practices.

I Just Called to Say Don't Mine It

(Music: I Just Called to Say I Love You by Stevie Wonder)

One day you said, you found some gold
Up in the North and the site was far and cold
You said you'll be a millionaire
In this remote site no inspector will be there
You'll make a pit, holes everywhere
Waste in the river and you said nobody cares
You'll be so rich, so will your family
Nobody will see where you'll dump your mercury
You just called to say you'll mine it
You just called to say that you don't care
You just called to say you'll mine the gold
And you said that with nobody you're gonna share

I didn't celebrate, I was quite surprised
A little later you will pay a higher price
I don't believe you're gonna tell
Environmentalists they all should go to hell
Mining is not a game, or a bordello
Mining must change; I have learned this with Marcello
I can help you you're not alone
To mine responsibly watch MINE 391
I just called to say don't mine it
I just called to say how much I care
If you mine and don't reclaim it
I guarantee your life will be a nightmare

Although in can be induced by human activity, Acid Rock Drainage (ARD) is a natural phenomena that generates sulphuric acid due to atmospheric oxidation of sulphide minerals. ARD occurs when a set of four elements (exposed sulphides, bacteria, air and water) are combined. The lyrics used in this parody are backed by the rhythm of a popular song from Village People, YMCA, and constantly ask the student why ARD is generated. The lyrics also call for the young miner's responsibility for the environment showing that there is an ethical commitment before the legal obligation.

Why ARD

(Music: YMCA by the Village People)

Young man, I understand you feel down
I said young man, see the acid on the ground
I said young man, this is going to the town
And the trout in the stream will die
Young man, when you said you don't mind
I say young man, look the iron oxides
I say young man, there's no way you can hide
Everything is red and you can't lie
You're gonna ask me ….why ARD?
You're gonna ask me ….why ARD?
The sulfides are there, bacteria everywhere
Full of water and lots of air
You're gonna ask me ….why ARD?
You're gonna ask me….why ARD?
Thiobaccilus is free, iron 2 becomes 3
Sulfuric acid you're gonna see
Young man, you are feeling alone
Call your work friends, before they are all gone
Ask for a hand, you cannot just postpone
And then fill the site with limestone
Young man, you cannot kill the bugs
I said young man, stop the water with plugs
You can cover it, all sulfides from air
And no more acid you will see there

One day you will find out….why ARD?
One day you will find out….why ARD?
The metals will leak, the fish will be sick
Please don't think this is magic
One day you will find out….why ARD?
One day you will find out….why ARD?
You should go back to school, take your friends with you
And you will learn what you have to do
Young man, I'm fed up with this story
I said young man, I cannot see the glory
Of just mine, and then run away
You must know somebody will pay
Young man, I'm sure that one day
You'll be an old man, and I'm sure you'll be proud
To say I made it, all the mines you reclaimed
They are clean and then no one complained
And then you'll say that you know ….why ARD?
And then you'll say that you know ….why ARD?
If you had known it before, you could have done more
And the image of mining won't be poor
And then you'll say that you know ….why ARD?
And then you'll say that you know ….why ARD?
You will see the solution for all this pollution
Cannot be just simple dilution

The above two songs are examples of the unique teaching methods used in MINE 391. In order to validate / verify the student's perceptions regarding these methods, a survey was distributed amongst the 93 students registered in the MINE 391. In total 78 students attended the class when the survey was distributed and the following section presents an analysis of the survey results.

Analysis

In order to have a better understanding of the student's perceptions of the use of songs as a learning tool a semi-structured questionnaire was developed. Some of the questions utilized a Lickert scale; the statistics from these questions are presented. The open-ended questions were created using concepts of content analysis: "a technique for making inferences by objectively and systematically identifying specified characteristics of messages" (HOLSTI, 1969, p.14). Two important categories sought in the student's responses were structure and content.

The first three questions identify the demographic of the class. The first two questions reveal that 79% of the students are male, 61.5% are in the 3rd year of school and 20.5% are in their 4th year. The third question shows that the average age is 21 years old. In questions 4 and 5 students were asked to name at least two things that they liked about the course and at least two thinks that they would change. Tables 2 and 3 compile the responses into two categories those related with class structure and those related to course content.

Table 2: things students like about MINE 391.

4. Name at least 2 (two) things you LIKE about MINE 391.	
Structure	**Content**
- Class enjoyable - Professor's interaction with class, casual atmosphere - Songs; Humour; Fun and involved - Extremely interactive - Profs make the lecture fun ... and interesting so that I can remember" - Love the relaxed atmosphere - "the professor's energy and approach to the subject is wonderful" - Interaction with students... entertaining - The professor makes learning cool - Enthusiastic professor - Stories told - His guitar - Informative music - Opportunity to engage with the topic - Promotes free thinking and allows us to grasp environmental concerns	- Social sciences behind mining - Effective teaching methods - The relevance of the information - Addresses important aspects of mining - Teaches me to think in a new way... it's a new perspective of mining - Lots of cases to illustrate theory - Very informative and information applies to reality - Very good / easy to understand methods of teaching complicated things - The material presented has the potential to be very difficult and boring but the professor presents it in a way that captures the attention of the class - Professor speaks well, doesn't feel like he is lecturing us but rather teaching - Lots of practical examples, stories, figures - Good exploration of all sides of issues

Table 2 shows what respondents like about the structure of MINE 391: "humour", "fun", "casual atmosphere", "interactive" were common responses. Additionally, "songs", "instructor's guitar", "informative music" and "his enthusiastic style" were highlighted as positive features. The casual atmosphere and relaxed environment allowed for more engagement and opportunity for free thinking as indicated by one student response about what they liked about the course: "Promotes free thinking and allows us to grasp environmental concerns". In the content category the survey reveals that songs are an effective teaching method, the information, case studies and examples are useful and very important for their professional lives and most importantly as highlighted by one response: [the teaching style]"Teaches me to think in a new way... it's a new perspective of mining". Another student pointed out that although the course content is complex and could lead to tedious classes the method adopted makes the class more enjoyable, stating: *"The material presented has the potential to be very difficult and boring but the professor presents it in a way that captures the attention of the class".*

Table 3: Things students would change about MINE 391.

5. Name at least 2 (two) things you WOULD CHANGE about MINE 391.	
Structure	**Content**
- More case studies; More assignments - More pictures; More videos - More songs - Change the schedule (days and time) - Change the location (small classroom) - More debate between students - Field trip to site; Guest speaker - More group projects; More presentations / skits - Make classes longer; Smaller class size	- More mathematics - Less subjective reasoning - Sometimes there is no definitive answer - Lots of chemistry - Simplify and better organize the course notes

Following the same methodology question five deals with aspects students would change about MINE 391. Considering that classes take place three days a week from noon to 1 pm and due to its popularity more than 90 students registered in this course. Very specific suggestions regarding structure were presented. The size of the class, suggestions to change the days (increasing the number of hours and reducing the number of classes) also change the time. Throughout the term students must present two case studies and a final group activity. The final activity is a group parody show in which students write their own musical parodies and perform the songs in an open event. Although there are already two case studies, the survey revealed that students are keen to engage in more group activities such as case studies, presentations, discussion and skits. The case studies are actual events that occurred in the mining industry and involve an analysis of a set of intertwined participants (community, government, non-government organizations, local families, Companies, Religious Groups, etc.) affected by the situation. Students are invited to recreate the environment and act-out their characters representing their groups in the format of a public and open debate.
These kinaesthetic learning activities are important gateways to developing body language and enhancing empathy because students play the roles of different stakeholders affected by mine activities. This activity provides them an opportunity to re-experience the situation and encourages empathy. Regarding the changes in the content few responses were collected which may suggest that no changes would be needed. Of the responses received one student asked for more mathematics, another replied that there is "lots of chemistry". Also, important information regarding the course notes were emphasised by the respondents suggesting that the amount of information and its organization could be revised.
Question 6 specifically sought to understand if the use of songs helped the student's understanding of the course content. A Likert scale ranging from "not at all" to "very much" was used. Results from this question are shown below in Figure 1; results show 31% of the students thought that songs are an effective tool to help understand lecture material. Similarly 48% responded yes and 21% believe there are some contributions. Question 6.1 elicited a written response from students explaining their reasoning for their response in Question 6. A selection of these responses is summarized in Table 4.

Table 4: Student's explanations for question 6.

Question 6.1 Explain your answer
They are very enjoyable and encourage me to come to class; however I don't think they help my understanding
They are memorable and it is more incentive to go to class. I remember main ideas much more than just listening to a lecture
The songs are catchy and make it easy to remember
They do include useful information that outlines the main points, which are easily remembered in the songs
It helps when it comes time to study, I can remember back to the song day and it triggers things that happened in that lecture specifically
Songs stick in memory more effectively than studying
Songs are an experience you remember more easily than a lecture
Excellent summary of the lectures
It keeps us engaged and entertained
I find music a really good educational tool
The songs don't deepen understanding of concepts but they encourage attendance
Presents material in a less intimidating situation
Obtain the content by more association of other senses
Learning while enjoying

An overwhelming majority of students responded favourably to the musical methods employed by the professor. Students felt that because the songs had repetitive chorus lines it is easy to recall the context and content of the lecture: *"The songs are catchy and make it easy to remember"* and *"It helps when it comes time to study, I can remember back to the song day and it triggers things that happened in that lecture specifically"*. By stimulating other senses, in this case musical, the instructor was able to reach students in another way. Songs provided a good summary and enhanced student's memory of course content in entertaining and enjoyable manner that provided incentive to attend class.

Conclusion and final remarks

We have long believed that science and technology will provide effective solutions to present and future environmental problems. Science and engineering education has become increasingly specialized in order to keep pace with great advances in technology. While this specialization is vital, it has left little time to consider the philosophical and ethical aspects of this progress. Long gone are the days when an expert scientist was also fully versed in the classics. Today's problems are often complex and intricate requiring more excellent technical skills to address them appropriately. There is an emerging awareness that the quality of the decision making is improved when one can draw on multiple intelligences. Raising awareness of the complicated situations that young mining engineers will face is essential to their future success. The UBC mining department is attempting to encourage this process and is enriching their technical education by targeting additional intelligences.

Based on the survey responses from students in MINE 391, going beyond the traditional lecture using songs and participative activities has enriched the student's education and provided additional motivation to attend classes. Musical parodies, case studies and skits are activities that contribute to an enhanced learning environment. These teaching tools target students' multiple intelligences while complimenting the fundamental techno-logical skills that are also essential. While time constraints prevented the inclusion of more case studies and other activities, the survey responses show an overall positive response from students about the course material and the professor's unique teaching methods. While the next generation of mining engineers will face an increasingly complex job of extracting resources with minimal impacts, they will be better-prepared to face these challenges with the ability to use multiple intelligences.

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