International Journal of Environmental Trends (IJENT)
http://dergipark.gov.tr/ijent
International Journal of Environmental Trends (IJENT)
2018; Vol. 2, Issue 1, 25-34
ISSN: 2602-4160
Turkish JournalPark ACADEMIC

ART TO GRADUATE MORE INNOVATIVE MINING ENGINEERING STUDENTS

M.Kemal Gokay[1], Melek Gokay[2]

([1] Selcuk Univ. Engineering Faculty, Mine Engineering Department, Konya, Turkey)
([2] N.Erbakan Univ. A.Kelesoglu Education Faculty, Fine Art Education Dept. Konya, Turkey)
Communication: mgokay@selcuk.edu.tr,

ABSTRACT

Engineers in all branches provide their plans or designed-items according to their knowledge and capacities. In design stage, engineers are expected to perform in creative manner to solve real world engineering problems. Mining engineers, similarly, should think differently to provide original plans and design products related with mines and mine operations. In order to graduate innovative engineers, different education methods have currently been applied in engineering departments. Importance of creative thinking in mining engineering and new engineering education methods were searched here through documents. Then basically, influences of art on engineering have been evaluated.

Received
22 March 2018

Accepted
27 April 2018

Keywords
Mining
Engineering Education
Art And Creativity
Effects Of Art On Engineering

International Journal of Environmental Trends, *2* (1), 25–34. Corresponding Author Email: mgokay@selcuk.edu.tr

INTRODUCTION

Mining engineers behave like system engineers to organize all related operation in mines to reach mine companies aims. Think about the lectures in universities to get an engineering degree on any branch. Engineering departments have different lectures to fulfill the background knowledge and information. Some lectures are theoretical and given in classrooms or auditoriums. There are laboratory works to be learned as well. There are also some lectures which are directly or indirectly related with engineering design and design

steps. Engineering departments have combined different lecture categories to educate their students. Diverse applications are also common in extra given lectures among universities. When mining engineering education in Turkey have been analyzed, it can be seen that students who have more opportunity to obtain practical mine related experiences and laboratory tests procedures in addition to theoretical lectures, are more ready for real world engineering applications. It can also be determined that; design related lectures and activities in mining engineering departments have occupied less lecture hours with respect to departments in architecture faculties. Although mine engineers contrarily need more design related lectures, because they have to plan and organize more complex workplace conditions. These include; ore body-country rock conditions, workers-machines interactions, excavation-stability situations, haulage-storage planning etc. Mine engineers have to prepare also plans for unexpected workplace circumstances (emergency action in case of mine accidents) in addition to regular mine planning. That means, mine design engineers should have capacity to think about all possible mine conditions including accidents and mine disasters as well.

It was aimed here to point out the importance of innovative and creative thinking in mining engineering design activities and its improvements by employing art related education. Engineering works include diverse studies and researches, different design products and plan-works surround us. It is important to figure out, how deep engineers think about their designs and plans? What are the influence factors to improve engineers' imagination and creative thinking? These have been analyzed by evaluating related art, design, engineering and mining studies reported in literature.

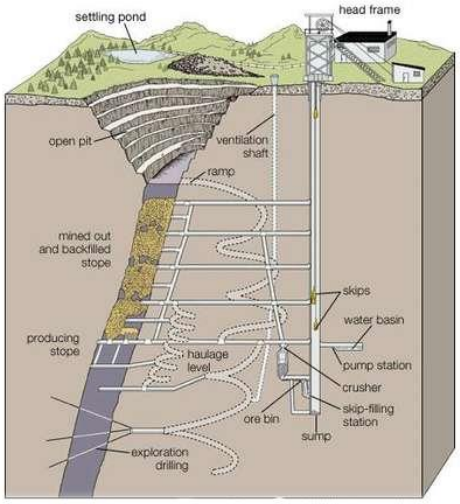
DESIGN AND VALUE OF ORIGINALITY

Mine engineers in general responsible all activities performed for ore excavation, stability of galleries, hauling the materials, and storing excavated ore near the mine site. Mine planning itself is complex and in somehow similar to city planning. Besides, especially underground

openings and workplace, mines have several elevation levels in three dimensional, 3D, underground conditions. Mine openings at each level should be designed by considering other openings' 3D stress distributions as well. Students in mine engineering departments have been educated by supplying knowledge and practical experiences on; mathematics, physics, chemistry, mineralogy, petrography, geology, engineering drawings, surveying, strength of materials, rock mechanics, stability of underground and surface excavations, excavation supports, tunneling, ore dressing, coal production and cleaning, mine planning (design), ore processing plant design, etc. These lectures themselves have their own information and professions differently and students are expected to be equipped well enough for these subjects. Answering the exam questions in lectures, might not necessarily cover designing and planning phases. In design lectures on the other hand, students have especially trained about their design abilities. They are required in these lectures to combine all their knowledge to produce realistic, engineered, solutions (plans, design products) for the given real world mine problems. They are expected to use their hypotheses, imaginations, reasoning abilities together with their science and drawing capacities in these lectures. Similarly, mine engineers working for mining companies should consider ore production procedures and they have to describe step by step how to realize the mine operations to reach predefined profit values. It has been personally observed that, students in mining engineering department of Selcuk University have especially been very sensitive on their own mine plan projects (at 4^{th} Grade lectures). They have tried typically to include all kinds of mine operations into their plans. Those operations have been seemed applicable and different at the beginning of their study. But later, students have usually realized that, the originality of their plans have limits. Merely the projects which were performed by curious and remarkable students have been picked as distinguishable. These students were frequently either hardworking students or somehow regular students but have diverse innovative ideas. High numbers of mine accidents in last

decades have gradually lead the governments take serious precautions in mining sector. In this historic path of mining, mine operations have gradually improved to handle higher production capacities together with safer workplaces. That means, mine engineers have gradually handled more parameters to obtain safe, efficient, profitable and applicable mine plans like presented in Fig.1. In time, mine plans are getting better and mine accidents have gradually been decreased. In order to reduce risk of mine accidents, mine engineers should think wide range of design parameters in general. However, most of the parameters originated through mine sites are uncertain in character and these create risks on mine safety. In addition, new technologies have also pushed mine engineers to modify their mine plans accordingly. Moreover safety and environmental issues at mine sites have to be followed according to supplied legislations as well. How it is possible to handle all these design variables including uncertain ones to reach applicable and well balanced mine plans? Reasonable answers definitely cover mine design parameters which should be considered *interdisciplinary manner* to obtain safer and profitable mine operations. Bieniawski for example analyzed rock mass related design considerations and Stacey mentioned [1] about his comprehensive design phases. They are as follows; *"a)Clarity of design objectives and functional requirements, b)Minimum uncertainty of geological conditions, c)Simplicity of design components, d)State-of-the-art practice, e)Optimization, f)Constructability"*. Each of these steps are supposed to be handled carefully due to their uncertain data content. Mine engineers should find out their own mine design methodology. This perception was also stated by Stacey [1] as following lines; "*there is no unique solution, and different engineers will produce different solutions; some solutions will work better than others, but all solutions should work* ". Then how mine engineers can improve their designing ability to offer meaningful solutions for their mining companies. Engineers at all levels of mining companies have known very well that, uncertainties in mine related data bring *"safety risk"* and *"economic recovery risk"* to mine

a)



b)

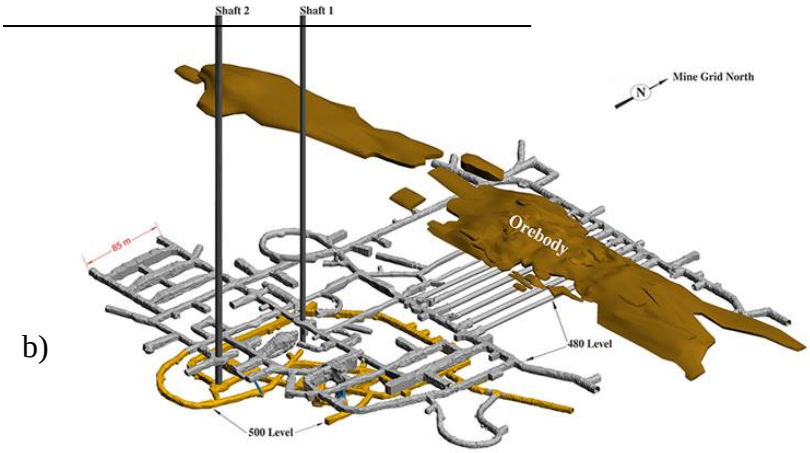


Figure 1. Underground mine openings in three dimensional mine space; a) Underground mine plans just under the open pit mines [2], b) Cigar Lake (Canada) uranium deposit and related mine plan [3].

plans [4]. What can be the method, mine engineers should follow? How can mine engineers decrease uncertainties and safety risks in their mine operations? Similar realities have long been considered and researched in mining engineering. Mine engineers have been supported by offering documentations on different rock mass classification methods and their rock support recommendations for example. Mine engineers can also follow criteria and approaches to reach approximate rock stress solutions by using physical and numerical analyses. They might also follow the experiences gained already at nearest mine companies. However there may be other ways or approaches which should be innovated to produce applicable mine plans. Mine engineers in these circumstances should accept and handle “mine

planning" with unusual, astonishing, way. At the end of planning procedure, mine engineers might even offer new methodologies for common mine operations. Thinking beyond the boundaries needs creative ideas and inventive actions. Who is going to offer those innovative plans? According to new engineering education approaches; engineering students have been forced to facilitate and boost up their creativity and thinking abilities before their graduation. Some of these approaches are; "ICTs-Information and communication technologies" [5], "STE-Science and technology/engineering" at Massachusetts state of US, [6], "SEAS-The school of engineering and applied science" at Princeton University in US, [7], "PBL-Problem based learning", [8]. It should be mentioned here that even secondary school educations in US and some other countries including Australia have been offered to modify their curriculum. New education methodologies have been proposed to enlarge students' creativity and innovations. These methods are *"science, technology, engineering and mathematics -STEM"* [9], and *"science, technology, engineering, the art and mathematics-STEAM"* [10]. Especially STEAM system was offered after recognition of *"art influences"* on students' original thinking capacities. Because art itself, is not only the cultural means of individuals but also it is important improvement mediator to amplify creativity and innovation capacity.

ART TO IMPROVE ENGINEERING INNOVATION

Artists have wide range of thinking and vision world compared to technically educated engineers. Musicians and fine artists can produce artistic products as far as their materials, equipments and application methods permits. In some cases, they use several methods in combination to reach their artistic aims. Artistic manners like abstracting, visual metaphors, paradoxes, myths, anomalies and analogies have been used by artists to visualize their creative ideas and thinking. Artists use also symbolic and semantic values in their products to improve their innovative inspirations. Burton etal. [11] stated that Grade 4,5,7 and Grade 8 students in US-Secondary schools, which obtained art-rich curriculum, had been commonly

higher scores through “Torrance creative thinking ability tests” with respect to the students at the schools which obtained arts-poor education curriculum in US. At this point, Chen & Ling [12] noted that *“creativity is the core value in every field of design”.* According to them creativity should be inspired instead of instructed, therefore they considered creativity was difficult to be taught by traditional sense. That means, researchers had already realized about the coincidences of creativity and art. For instance, famous work of art called ”Mona Lisa” was painted by Leonardo Da Vinci who have many different engineered machine plans as well (Fig. 2a). When artist Salvador Dali is under study, his imaginative world is surprisingly different (Fig.2b). These samples present limitless imagination world of artists.

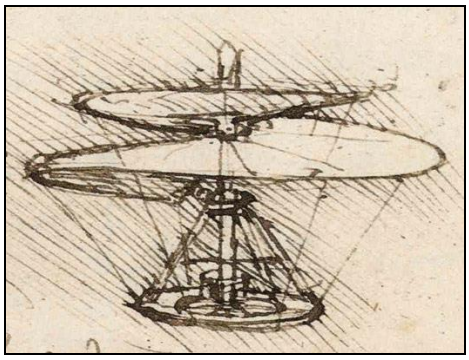
a)  b) 

Figure 2. Flying machine designed by Leonardo Da Vinci [13] and artwork of Salvador Dali [14] are the samples which show their creativity and imagination.

Creativity, improved through art, has currently been utilized in engineered virtual reality computer programs. Futuristic drawings, imaginary panoramic paintings, imaginative space life paintings, enlarged anatomy drawings, imaginary world in futuristic movies are fundamental artistic bases of those virtual applications. Virtual reality teaching systems have already been tested at a mining engineering department in Australia [16]. These programs virtually presented mining related information and problems in classrooms (Fig.3). When visual features of mine environment, presented through these programs, are handled artistically, students might feel actual mine conditions in classroom conditions.

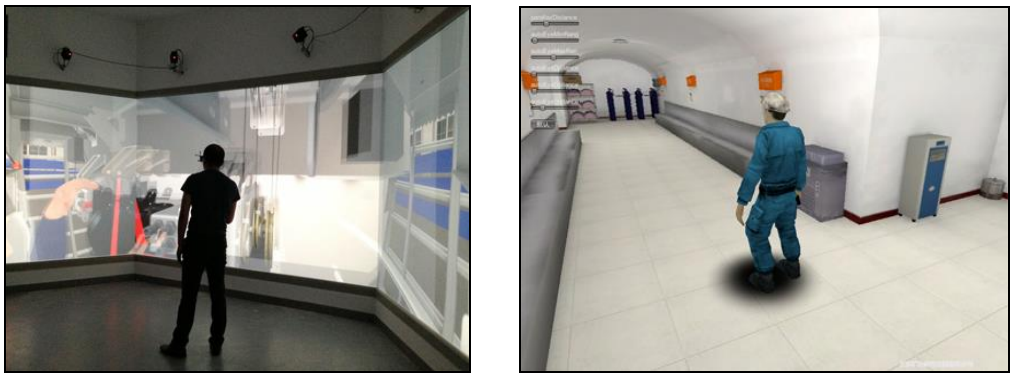


Figure 3. Virtual reality applications for mining engineering education [15].

It is obvious that pure or plane visualization of underground galleries, tunnels etc. can not catch "underground feelings". In order to get more realistic reactions from students in virtual reality teaching applications, information supplied through them should cover full features of mine sites. Artists may include additional effects to increase human feelings in scenarios presented. Achieving these results depends on creative mine simulations which should professionally be programmed. Lederwasch explained how art was used to influence the attendance ideas during *"Vision 2040"* activities. These activities were about "long-term national benefit from Australia's minerals" [17]. Sawyer [18] also pointed that countries had gradually transferred their education systems to facilitate creativity. He wrote that; "*The European Union designated 2009 "The European Year of Creativity and Innovation," proclaiming that "Europe's future depends on the imagination and creativity of its people*". In last two decades creativity and creative learning activities have researched widely. Sawyer however, reviewed the literature to determine if there were models of "creative teaching and learning" which had been supplied for "art and design education" practices. He identified 65 related articles published until 2017 in literature. He said, simply 11 articles of them were connected to "art and design" themes. Art itself are handled widely in societies. Art and culture have then shaped societies as different traditions. Thus, art and related products have governed the life of individuals in times. When we think about mine engineers and its

responsibilities, artistic visions which should be obtained at schools (secondary school, high school and university) are straight influencing factors on these engineers' innovation and creativity capacities. Because art itself has manipulating effects on thinking and imagination powers of students. This enhancement is crucial nowadays to graduate more innovative mine engineers.

CONCLUSION

Art and related activities have directly influenced some engineering activities. Some others on the other hand have indirectly been influenced by art and artistic creation processes. Creative thinking and innovations which are obtained while producing artifact are valuable assets. Novel education systems offered for students in engineering faculties run for those innovation and enhancement of original thinking. Ores and coal reserves are getting decreased gradually due to high consumption in this modern world. The question is not easy to answer here, but it should be asked that; where the ores and energy sources are which mine engineers will plan to excavate in future. These reserves may be located very deeply in earth crust, or they might be obtained from other planets, moons or asteroids. That means mine engineers in near future have to design their mines very differently. Therefore they should be more creative in their projects. Currently, new environmental issues and legislations require innovative mine design procedures to convince societies about the minimum harmful effects of mining activities. STEAM related education levels and new education systems offered for engineering education aimed more comprehensive graduates in knowledge, practices and creativity. Art at this point helps students to improve their engineering imagination, creative thinking and originality in their designs. Art itself are valuable possessions in new engineering education systems to enlarge students innovations.

REFERENCES

[1]. Stacey, T.R., 2004. The link between the design process in rock engineering and the code of practice to combat rock fall and rockburst accidents, *The journal of the South African institute of mining and metallurgy*, Jan./Feb. 2004, pp29-33.

[2]. Hamrin, H., 1980. *Guide to underground mining methods and application*, Atlas Copco, p39, Original from Pennsylvania State University, Digitized, Oct. 9th, 2009.

[3]. Cameco, 2015. Cigar Lake (Canada) uranium deposit mine, Cameco, 2015 *Annual Report*, Internet web address, https://www.cameco.com/annual_report/2015/mda/our-operations-and-projects/uranium-operating-properties/cigar-lake/

[4]. Gokay M.K. and Shahriari, M., 2016. Design: Relation with occupational safety in mines, *8th International conference on occupational safety and health*, 8-11 May 2016, Istanbul, Halic congress centre, paper-0730, pp722-729.

[5]. Cha, J. and Koo, B., 2011. *Policy Brief, ICTs for new engineering education*, UNESCO, United Nations Educational Scientific and Cultural Organisation, Unesco Inst. For Information Tehnologies in Education. Feb. 2011, ISSN 2221-8378.

[6]. Chester, M.D., 2016. Massachusetts Science and Technology/Engineering Curriculum Framework, (Editor), Massachusetts Department of Elementary and Secondary Education, Malden, MA, US, www.doe.mass.edu/frameworks/current.html.

[7]. Eisgruber, C.L. and Lee D.S., 2016. Engineering and Applied Science at Princeton University, A statement, https://www.princeton.edu/strategicplan/files/Response-to-SEAS-Task-Force-Report.pdf, Retrieved 9th Mar. 2018.

[8]. Neufeld, V.R. and Barrows, H.S., 1974. The "McMaster Philosophy": An Approach to Medical Education. *Journal of Medical Education*, V49, Nov1974, pp1040-1050.

[9]. Gonzalez, H.B. and Kuenzi, J., 2012. *Science, Technology, Engineering, and Mathematics (STEM) Education: A Primer*, Congressional Research Servise, 7-5700, R42642, CRS Report for Congress, US.

[10]. Jolly, A., 2016. *STEM vs. STEAM: Do the arts belong?*, www.wiki-zero.com, EdWeek.org. Education Week: Teacher. Retrieved 6th Sep.2016.

[11]. Burton, J., Horowitz, R. and Abeles, H., 1999. *Learning in and through the arts: Curriculum implications*, p46, Center for Arts Education Research Teachers College, Columbia University, US.

[12]. Chen, K. and Ling T., 2010. Creativity-provoking design education based on Jungian psychoanalysis theory, *Procedia social and behavioral Sciences*, V2, pp4555–4560.

[13]. Bartoli, G., Borsani, A., Borri, C., MArtelli, A., Procino,L. and Vezzosi, A., 2009. Leonardo, the wind and flying sphere, *EACWE-5, 19-23 July 2009*, Florance, Italy.

[14]. Dali, S. 1937. Ship with butterfly sails, Expressionism. https://tr.pinterest.com/pin/767511961467768833/?Ip=true, Retrieved 21th Mar. 2018.

[15]. Chen, Z., Liu, L. Qi, X. and Geng, J., 2016. Digital mining technology-based teaching mode for mining engineering, *iJET*, V11, N10, pp47-52.

[16]. Harrod, J.R., 2016. Enhancing Mining Education through the use of a Scenario-based Virtual Reality Simulation, *Master of Philosophy thesis*, The School of Mechanical and Mining Engineering, The University of Queensland, Australia.

[17]. Lederwasch, A., 2012. Scenario art: A new futures method that uses art to support decision-making for sustainable development, *J. of Futures Studies*, V17, N1, pp25-40.

[18]. Sawyer, R.K., 2017. Teaching creativity in art and design studio classes: A systematic literature review, *Educational research review*, V22, pp99-113.