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GIFTS: Redesign of Principles of Mining Engineering Course

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Abstract

This GIFTS paper details the redesign of the Principles of Mining Engineering course, which aims to enhance first-year student success as mining engineering students through career preparation, laboratory safety, and involvement with student organizations. Structured as a one-hour lecture and one-hour lab at the Experimental Mine, the course uses active learning techniques and hands-on lab experiences. Student organizations such as the Mine Rescue Team and Mucking Team provide practical experience while introducing students to extra-curricular opportunities. The course redesign demonstrates an enhanced first-year student experience measured by engagement and readiness for academia and industry. This paper will outline the course's development, student feedback, and plans for further refinement.

Introduction

Mining is crucial to meet the global demand for mineral resources. Thus, introductory mining engineering courses are essential in preparing first-year students with the necessary skillset to be successful in their future courses, internships, and careers. The transition to university can be demanding for first-year engineering students as they will face more rigorous coursework, unfamiliar work environments, and more stringent professional requirements [1]. The Kolb Experiential Learning Cycle (Spiral) where students cycle through concrete experience, reflective observation, abstract conceptualization, and active experimentation is a framework that can make learning difficult or new concepts easier [2]. In recognizing the opportunity to implement these concepts, the Principles of Mining Engineering course (MIN ENG 1912) underwent a comprehensive redesign to better support first-year mining engineering students' academic, professional, and community development. The redesign of this course was made possible through an internal seed grant to integrate the Kern Entrepreneurial Engineering Network (KEEN) principles into a course [3].

First-year engineering students enter university with several uncertainties. Incoming students can feel isolated if they did not arrive with a cohort of friends [4]. They can be confused by college requirements such as prerequisite classes or how to find semester offerings. First-year programs aim to bridge the gap by improving student motivation and retention, stimulating interest in the field, and initiating professional development skills [5]. In addition to a college-wide program to introduce students to campus life, individual departments typically have introductory courses for their programs. These courses typically are short 1-2 credit hour lectures to introduce the main topics of the engineering field. These courses offer a great opportunity to implement proven methods from successful college-wide first-year programs into a targeted major-specific delivery.

Prior to the redesign, MIN ENG 1912 followed a conventional lecture-based format that introduced mining terminology and discrete lectures for a variety of mining topics. The redesign intended to improve the experience for first year students and achieve the following goals: 1. Improve performance in future classes by fostering curiosity about mining; 2. Increase successful application and completion of internships by providing early industry training; 3. Increase student retention by creating both a sense of community and an introduction to campus support systems.

Course Development

The redesign's primary focus was incorporating the KEEN principles; however the course was also identified as a place to enhance the first-year experience. The redesign began with a thorough assessment of the previous course structure, student feedback, and alignment with industry and university standards whilst incorporating KEEN principles. The two-credit-hour lecture was modified to be a one-hour lecture and one-hour lab session each week held at the experimental mine. The lecture sessions incorporated theoretical concepts with interactive activities, followed by a lab session with hands-on experiments facilitated by industrial practices and student organizations.

The framework for the class schedule was developed to simultaneously address the three C's of the KEEN framework and the unique needs of first-year students. The five pillars of this course are listed below, and Appendix A shows how they relate to the course modules.

1. Introduction to campus and community to encourage participation in student groups.
2. Connection to previous experiences with Minecraft to foster curiosity about future lessons.
3. Narrative approach to the mining method to connect seemingly unrelated fields.
4. Depth into engineering topics related to safety to create a sense of value.
5. Career preparation in line with MSHA standards to prepare students for internships.

The beginning modules focused on introducing students to the experimental mine site and various student groups in the mining department. By lecturing students on the rules and regulations held at the Experimental Mine, they will be better prepared for not only navigating the underground working but also how to be safe while completing laboratory experiments underground. Members from eight student organizations introduced the group and activities. The students were able to sign up to attend future info sessions and start participating in student organizations right away. The Mine Rescue Team introduced students to a disaster response scenario, where students must safely navigate a room and pillar mine while checking rock stability and ventilation conditions. The Mining Games Team introduces students to the proper use of personal protective equipment and safely working with hand tools (both required by MSHA) while competing in classic mining events such as Swede saw, hand steel, and track lay contests. This allows new students to be introduced to the organizations while learning, in hopes of persuading them to become involved within the department.

Minecraft Education Edition was used to introduce a variety of surface and underground mining methods. Most first year students are not familiar with modern mining practices, but are exposed to popular media like Minecraft, which usually shows a poor representation of modern mining. This course developed two activities to bring real world mining into the game environment. First, introducing a competitive game to extract the most value from a dipping coal seam, and second to artistically recreate a real mining method in the game.

The next few lessons used a sequential narrative to connect parts of the mining cycle. During labs, the class: 1. Broke boulders using explosives to make the ore easier to transport; 2. Moved the material from the "pit" to the "processing plant" in teams and conducted a time study on the average and variation of each operator; 3. Crushed and screened copper-coated iron bbs embedded in concrete cubes to liberate "ore", improve density separation in a pan.

The rock mechanics and ventilation lessons introduced some of the deeper engineering concepts for this course. These two lessons tie directly into miner safety with the real-world consequences of errors very apparent. This helps motivate students by connecting engineering design to the value of worker safety in industry.

Finally, the semester ended by introducing the Mine Safety and Health Administration's (MSHA) CFR 30 Part 46 and 48 requirements for new miner training. These regulations mandate comprehensive safety education, covering hazard identification, safety protocols, and practical mining skills essential for both surface and underground operations. This was conducted throughout the class, but these lessons covered specific topics like first aid, miners' rights, and hazard identification explicitly to comply with the regulations and prepare students for working in labs on campus.

Student Feedback

Quantitative

At the end of each course, students complete a voluntary course evaluation of teaching (CET), where a numerical value is assigned for overall teaching effectiveness. The scores for each semester the course was offered by the professor can be seen in Table 1. Fall 2024 was the first offering of the new course format. Unfortunately, with a small sample, the data is confounded with the experience of the professor and time of year. However, the highest score was achieved after the modifications to the class, which shows students were receptive to the changes.

Table 11: CET Scores from Student Evaluations. *Redesigned course

Semester	Spring 2022	Spring 2023	Spring 2024	Fall 2024
CET Score	3.12	3.25	3.44	3.59*
Enrolled	15	13	28	43

Qualitative

In addition to the numerical score, two open ended questions were asked: 1. With regards to teaching, what are the strengths of the instructor? 2. What suggestions do you have for improving the quality of instruction? For strengths students highlighted "engaging" and "fun" activities that were well matched to lecture material and the overt industry applications. During the semester, one student said they shared the Minecraft homework with their friends and students not even in the class wanted to do the homework for fun. The suggestions for improvement mentioned more time to complete lab activities and more opportunities to attend field trips.

Future Refinement

The initiative for this class is to keep refining to meet the needs of students to optimize education for future mining engineers. The lab for this class was split into two sections. Half the students attended a lab immediately before the lecture, while the other half attended a lab immediately after. This split did not seem to cause a decline in outcomes but could be more clearly explained at the beginning of the semester. Some students may prefer learning with hands-on work prior to a classroom lecture, while others may prefer reading and listening before applying the information hands-on.

The class attempted to use hands-on activities for most labs. However, as a first iteration with higher enrollment than initially expected, some individual work was exchanged for group work or class demonstrations. It was noted that individual hands-on work engaged the students, but labs with unevenly distributed group work based on assigned roles or labs with instructor-led demonstrations had lower engagement.

Improvements can be made by methods of cycling materials between small groups to ensure most/all students can participate. Low engagement can also correlate to large amounts of activities pushed into short time spans without fundamental structure. This can be improved by exchanging detailed explanations during lab with detailed pre-lab documents, group formation, and role assignments.

Conclusion

The redesign of MIN ENG 1912 has improved the first-year experience for mining engineering students. The course enhances the first-year experience by welcoming students into the campus community, engaging students with active learning, and preparing students for industry. Student feedback emphasizes positive transformation, as demonstrated by improved course evaluation scores provided by students after completion of the course. Future course improvement includes enhancing lab schedules, improving student involvement within lab activities, and optimizing student engagement during large group activities. By consistently refining course structure and addressing student feedback, MIN ENG 1912 is well-positioned to develop skilled mining engineers. Fostering curiosity, connections, and value-driven material enhances the educational experience for first-year students in the introductory mining engineering course.

References

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APPENDIX A – Design Pillars Aligned to Course Modules

Pillar	Module	Lecture Topic	Detail
Campus Welcome	1	Introduction and Mine Tour	Draw a map of the mine from memory
	2	Student Group Welcome	Mine Rescue Competition
			Mining Games Competition
	3	Career Planning	Critical Path Analysis on Curriculum
Connection to Prior Experience	4	Surface Mining	Minecraft – Computer programming and economic analysis
	5	Underground Mining	Minecraft – Open ended "art" project
Sequential Scaffolding	6	Explosives	Boulder Breaking Demonstration and Environmental Compliance
	7	Ore Handling	Time Study and Statistical Analysis
	8	Mineral Processing	Crushing, Screening, and Gold Panning
Engineering Depth and Value	9	Ventilation	Comparison of Natural, Historic, and Modern air movement
	10	Rock Mechanics	Pillar Strength – Theoretical vs Actual Strength
			Paper bridge design contest
Industry Preparation	11	Miner Rights and Responsibilities	Industry requirements
	12	First Aid	Role play first aid scenarios
	13	Hazards Identification and Mitigation	Risk Assessment and hierarchy of controls