Emotions and Course Learning Outcomes in Geology Fieldwork among Petroleum Engineering Undergraduates

Article history
Received
17 July 2023
Received in revised form
12 December 2023
Accepted
12 December 2023
Published online
23 December 2023

Akhmal Sidek[a*], Chong Aik Shye[b], Nurul Huda Zamzuri[c], Ahmad Nabil Nasir[d], Zakri Tarmidi[e]

[a,b]Petroleum Engineering Department, Faculty of Chemical & Energy Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia.
[b]Research Management Unit, Universiti Teknologi Malaysia
[c]Department of Technical and Engineering Education, Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia.
[e]Department of Geoinformation, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia.
**akhmalsidek@utm.my*

Abstract
Quantitative approaches have been conducted on petroleum engineering students' emotions before and after fieldwork experiences affected course learning outcomes. The study found positive-feelings experiences increased from pre-field to post-field such as confidence about what is expected and gladness that they are going to the field which is learning outside of the classroom. However, there is a small number of students worried before the fieldwork is conducted that they need to adapt to a new environment. Positive feeling experiences emotions shows a significant relationship with learning outcomes as compared to negative feelings; it has no significant value. Overall, the importance of these findings depends on improving awareness of the components that influence students' learning experiences and highlighting the importance of considering the complete spectrum of emotional and learning-related aspects into consideration when creating a fieldwork learning program.

Keywords: geology fieldwork, petroleum engineering undergraduate, emotions, course learning outcomes.

1. Introduction

In recent education, a variety of skills are given preference, including academic, technical skills, competently communicational, social in nature and community, and global capabilities. It is crucial to develop student's competencies and spark their innovative thinking. In addition, it may grow as a result of pedagogical innovation, training, and rapid construction processes. Shifting from one place to another from eternity to reality is crucial for the new teaching methods to be successful. Several factors, including student emotions, feelings, and attitudes, may influence the learning outcomes (Huang et al., 2015). Therefore, constructing practical fieldwork knowledge and abilities is seen as one of the core goals of education across several fields, particularly in the geoscience and petroleum engineering disciplines.

Geology fieldwork is an essential component of petroleum engineering undergraduates because it provides the necessary foundation for understanding geological formations (Cannon, 2019). It has been recognized as an efficient method of education in the geoscience fields. Meanwhile, petroleum engineering involves the exploration, drilling, and production of oil and gas from reservoirs, which requires a detailed understanding of the geology of the area. During geology fieldwork, geologists collect data on the rock formations, sedimentary layers, and structural features of the earth's crust. They use various techniques, including mapping, sampling, and analyzing lithology, rock, and sediment samples to identify potential hydrocarbon reservoirs. This data is then used by petroleum engineers to design drilling and production plans that maximize the recovery of oil and gas from these reservoirs (Basu, 2022).

Petroleum engineers rely on geologists to provide accurate information about the area's geology, including the depth and thickness of sedimentary layers, the type of rock formations, and the presence of faults or fractures that can affect the flow of hydrocarbons. They use this information to design drilling plans that take into account the unique characteristics of each reservoir, such as the permeability and porosity of the rock formations, to ensure that the maximum amount of oil and gas can be extracted. Thus, geology fieldwork provides the

necessary foundation for petroleum engineering students by providing detailed information about the geology of an area, which is essential for designing efficient and effective drilling and production plans (Gluyas & Swarbrick, 2021).

Generally, undergraduate petroleum engineering students participating in geology fieldwork can provide valuable hands-on experience and practical knowledge that can help their future careers. Fieldwork can also help develop important skills such as critical thinking, problem-solving, and teamwork (Raath & Golightly, 2017). It can teach how to work effectively in a group, communicate with other team members, and coordinate efforts to achieve a common goal. The student may have the chance to interact with geologists and other petroleum engineers working in the field, which can help build relationships and learn about potential career paths. Furthermore, participating in geology fieldwork as an undergraduate petroleum engineering student can provide valuable knowledge, practical experience, and important skills that can help them succeed in their future career.

However, there are several limited factors in the student learning process in fieldwork mode such as prior knowledge and experience pre- and post-execution of fieldwork, emotions, and lastly impact on learning outcomes. Students' experiences of the learning environment affect the methods that they use, which can in turn affect learning outcomes. By encouraging the desire to study for own purpose and improving cognitive engagement, motivation serves as an intrinsic reason for learning. Extrinsic motivation, on the other hand, encourages the urge to complete tasks to obtain something unrelated to the action itself. Therefore, this study attempted to evaluate learning geology fieldwork influence factors that support student learning, especially for undergraduate petroleum engineering students.

Fieldwork Programme Outcomes

Outcome-based education (OBE) is an approach to education that focuses on defining and measuring the outcomes that students are expected to achieve by the end of a particular course. The outcomes are based on the knowledge, skills, and attitudes that students should have upon graduation. In the field of engineering, the Engineering Accreditation Council (EAC) is responsible for accrediting engineering programs in Malaysia. The EAC uses an outcome-based approach to evaluate the quality of engineering programs teaching and learning (T&L) and to ensure that they meet national and international standards. Hence, by adopting an outcome-based approach, engineering programs can ensure that their curriculum is aligned with the needs of industry and society and that their graduates are well-prepared for the workforce.

The OBE has been implemented in this case study university since 2010. The implementation of OBE was a response to the Ministry of Higher Education's (MOHE) call to enhance the quality of higher education in Malaysia by aligning the curriculum with the needs of the industry and society. These learning outcomes were aligned with the Malaysian Qualifications Framework (MQF) and the EAC requirements. The petroleum engineering undergraduate program in this case study university was established in 1983. Over the years, the program has undergone several changes and improvements to keep up with the evolving needs of the industry and advances in technology. In 2020, the program was revised to align with the OBE framework released by EAC, which emphasized the importance of defining clear and measurable learning outcomes for students.

The EAC has defined twelve Programme Outcomes (POs) that align with the MQF and the Washington Accord, which is an international agreement that recognizes the equivalence of engineering qualifications among signatory countries (Engineering Programme Accreditation Manual, 2020). The PO included Engineering Knowledge (PO1), Problem Analysis (PO2), Design or Development of Solutions (PO3), Investigation (PO4), Modern Tool Usage (PO5), The Engineering and Society (PO6), Environment and Society (PO7), Ethics (PO8), Individual and Teamwork (PO9), Communication (PO10), Project Management and Finance (PO11) and Lifelong Learning (PO12). There are a variety of assessment methods that are aligned with the POs and designed to measure students' attainment of the POs. These assessment methods may include written examinations, assignments, laboratory work, projects, fieldwork, and industrial training. Through a high level of stakeholder participation, the course and program-level assessment of POs for continuous quality improvement (CQI) will be carried out.

The faculty has decided that the geology fieldwork subject will be taken during year three in semester one. The total student learning time (SLT) for geology fieldwork is 41 hours and depicted as one hour credit with four-course outcomes (CO) in the petroleum engineering course. The university has been setting more than 65% of COs as Key Performance Indicator (KPI) achievement. Table 1 shows PO and CO mapping in geology fieldwork subjects. Additionally, the faculty decided in OBE and taxonomies level for fieldwork are C1 (Knowledge), C2 (Comprehension) and C3 (Application). The T&L in fieldwork subjects are student-centered and cooperative learning with implemented outdoor class activities and problem-based learning. The learning expected to meet several objectives which are an ability to practice competent field skills; construct a geological map referred to field-based data and ability to demonstrate professional manners, systematically, and work as a team.

Table 1. PO and CO with bloom taxonomy of geology fieldwork

CO	Description	Taxonomy	PO
CO1	Demonstrate rock units and geologic structures such as beds, folds, faults, and joints.	C1	PO1
CO2	Illustrate the stratigraphy and geological history of Peninsular Malaysia and the distribution of different kinds of rocks in Peninsular Malaysia or North and Central Sarawak.	C2	
CO3	Carry out compass directions or bearing, the strike, and dip of bedding or joint planes, and construct simple geological mapping using the compass-step method.	C2	PO2
CO4	Use resources and technology to communicate and demonstrate knowledge and experience acquired from the fieldwork.	C3	

The evaluation of this fieldwork subject is formative assessments with rubrics which are Field Notes (20%), Geological Interpretation (20%), Teamwork (10%), Peer Evaluation (10%), and Final Report (40%). The fieldwork timing within one week before a new semester starts students and staff must share living and social areas during fieldwork due to nearby accommodations, where all student and technical staff have few and simplistic facilities.

Emotions and Learning Outcomes

Learning and emotions have a more sophisticated interaction. Positive emotions have a less predictable impact on learning, despite very consistent findings showing that elevated negative emotions, including anxiety, usually impede learning by creating an unnecessary cognitive load (Fraser et al., 2012). In addition, based on previous studies, positive emotions have been linked to increased motivation and improved problem-solving in learning (Um et al., 2012). However, other studies have shown a reverse impact, showing that learning and positive feelings have a negative relationship (Oaksford et al., 1996). It is unclear under what circumstances positive feelings promote or inhibit learning, nevertheless, it has been proposed that since all emotions provide additional cognitive stress, the overall impact of positive emotions may rely on how they react to additional forms of cognitive load (Fraser et al., 2012).

2. Methodology

The respondent selected for this study is 60 undergraduate students who have registered geology fieldwork subject in semester 1 session 2022/2023 and they are also divided into small groups. This annual geological fieldwork is located in and around the East Coast of Malaysia Peninsular which observes several outcrops along road cuts, beaches, quarries, and limestone caves. Three main types of rock can be seen during fieldwork and consist of igneous, sedimentary, and metamorphic rocks. Moreover, the geological features related to geomorphologies, mineralization, fossils, structures, and geological engineering construction input were observed.

The measurement instrument conducted in this study is a self-administered structural questionnaire and it consists of two sections. The first section is for demography of respondents that only considers genders and cumulative grade point average (CGPA). The study used pre- and post-experienced fieldwork observations modeled by Stokes and Boyle (2009). This second section to measure positive or negative feelings about fieldwork which are described by ranks indicated by yes (1) or no (0). Description of a negative and positive feelings of the pre-and post-fieldwork is depicted in Table 2. The Course End Report (CER) developed by the faculty is a report summary of the points, learning outcomes, conclusions, and responses from an educational program from the respective subject. It may be used to assess the effectiveness of the learning process, highlight areas that need improvement, and report to the faculty about learning findings.

Table 2. Negative and positive taxonomy of feelings achievement description (Stokes & Boyle, 2009).

Pre-Fieldwork	
Positive	Negative
• Happy • Relaxed • Can't wait • Eagerly anticipating • Confidence about what expected	• Concerned • Worried • Don't want to go • Don't know what to expect • Apprehensive
Post-Fieldwork	
Positive	Negative
• Want to go again • Learned a lot • Glad we had to go • Enjoy it • Worthwhile	• Lived up to my fears • Did not enjoy • Didn't know what to expect • Wish not compulsory • Found hard

Moreover, the questionnaires were distributed in their e-learning system attached with a Google Form

link, and collected before and after fieldwork. Furthermore, the statistical analysis used a series of one-way analyses of variance (ANOVA), where positive and negative feelings for both pre- and post- fieldwork as the independent variables, and CO achievement was taken as the dependent variable (Figure 1). Hence, the level of significance for analysis was set to 0.05. Finally, all the data were analyzed by using the Statistical Package for Social Science (IBM SPSS) v. 22.

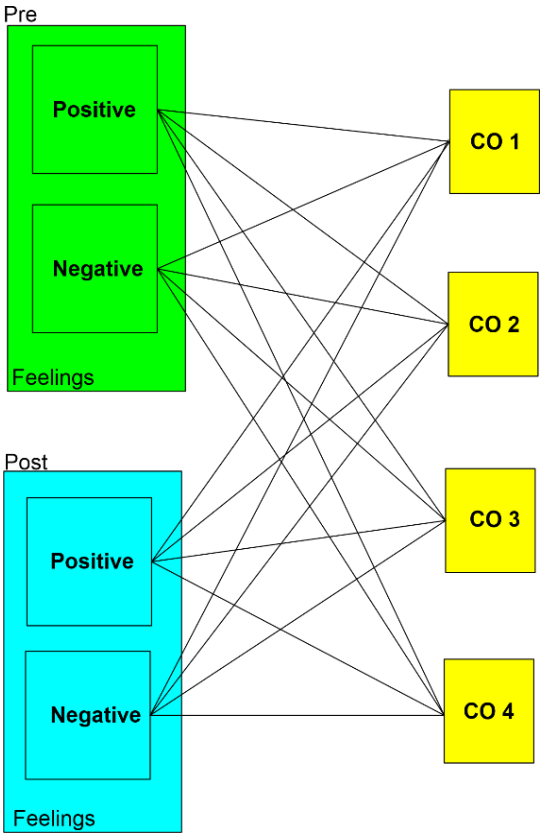

Figure 1. Conceptual framework

3. Results and Discussion

For the demography measure in the reflection and anticipation in this fieldwork, a total of 61 respondents were divided into two sections, and the maximum for each section is 30 students who participated in the study. The respondents were separated into small groups and each group contains 5 students. Figure 2 depict the majority of the respondent are female (53.1%) and less than half are male (46.9%). The results in line with findings from Shahzad et al. (2020) mentioned that in 2020 majority of students in universities in Malaysia were female compared to male. This is not surprising as reported by Khazanah Research Institute (2023) found in 2021 female students from Malaysian high institutions made up 53.2 percent based on Graduate Trace Study (GTS).

Figure 3 shows the CGPA among respondents indicating most of them had better academic performance with 58.5 percent. It has been discovered that cooperative learning processes will raise students' attitudes toward the subject and improve their results more than traditional approaches (Zakaria et al., 2010).

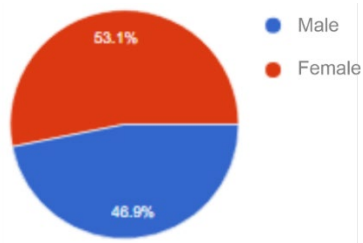

Figure 2. Gender distribution.

More possibilities for students to get involved in the conversation and problem-solving skills developed by the petroleum engineering program. It is evidence exists indicating the teaching and learning process had a major impact on students' academic success. To motivate students to actively participate in class, lecturers need to enhance their methods of instruction.

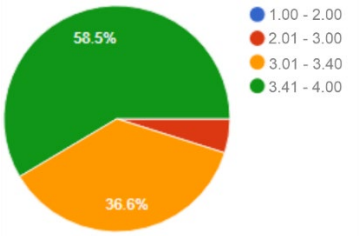

Figure 3. CGPA distribution.

Emotions associated with success in learning may not only be the results of accomplishing activities and outcomes, but they may also be crucial for future education (Pan et al., 2022). The influence of emotional achievement on pre- and post-fieldwork was examined (Figure 4). It can be seen that most of the respondents' feelings were positive at the beginning of fieldwork about 87.6 percent. However, there are some respondents about 12.4 % answered 'yes' with negative feelings before fieldwork started. Most negative feelings are indicated by worry about fieldwork exercises. It is probably because they are learning to adjust to various environments and a culture has likely been difficult for them before to the field. As mentioned by Punch (2012) fieldwork presents complicated practical, emotional, and individual challenges that are still hardly ever addressed in methodological rationales. In positive feelings, most of them feel 'confidence about what is expected'. It could be they already prepared and discussed among their senior about fieldwork experiences.

After the fieldwork excursion, the negative feelings reduced to 2.3 %, and still a small number of them answered "don't know what to expect'. This is because managing orders of magnitude's amount of geological data is challenging. In the field, students need to visualize geological data such as structures of the

outcrop, learn about demand at work, and analyze strike/dip. Furthermore, limited imagination skills (cognitive) may affect students understanding of geological structures in the field (Shipley et al., 2013). Pre- and post-fieldwork emotions in statistical data were shown to differ significantly (Table 3), it could be students need to travel to a new locality or station and get to know staff. Nevertheless, positive feelings found increased from before and after fieldwork realizing teamwork as a valuable component of learning then realizing teamwork as a valuable component of learning (Nyarko & Petcovic, 2023). The outdoor program was intended to promote both independent functioning and constructive and progress in both categories is evidenced by students' gaining confidence in their ability to make decisions on their own in cooperation in the field.

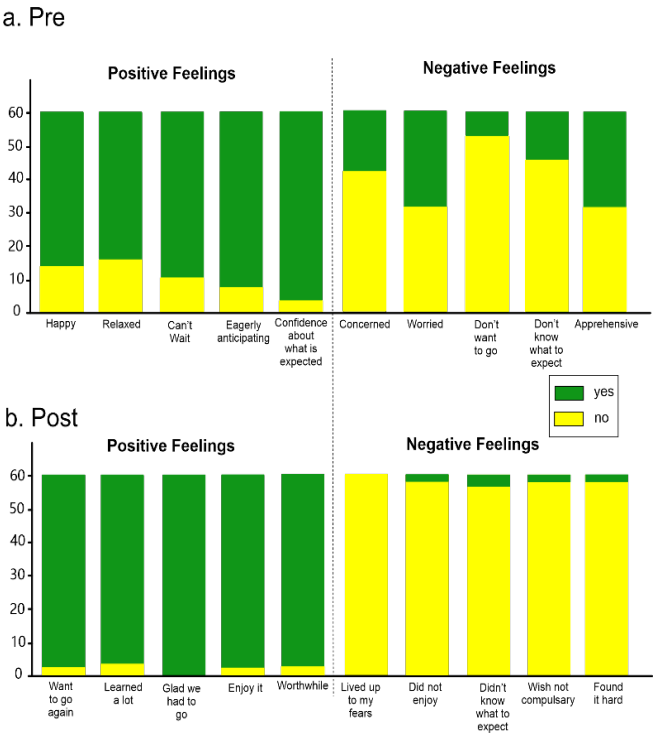

Figure 4. Respondent's feelings before (a) and after (b) fieldwork

Table 3. Statistical for the pre-and post-fieldwork score that several students answered 'yes' shown by means.

Pre-Fieldwork	n	mean	SD
Positive	61	0.876	0.919
Negative	61	0.124	0.632
Post-Fieldwork	**n**	**mean**	**SD**
Positive	61	0.977	0.262
Negative	61	0.023	0.441

As shown in Table 4, all COs indicate above KPI (>65%) as standardized by the university. This indicates most of the students can analyze and demonstrate geology fieldwork. It also reflected the effectiveness of T&L at the field deliverable in gaining understanding among students. According to Feder (2019), it represents the finest practice in pedagogy to accomplish continuous learning outcomes in Petroleum Engineering students in the United States.

Table 4. Course learning outcomes achievement summary

Course Learning Outcome	Average (%)
CO1	84.7
CO2	85.1
CO3	84.5
CO4	84.6

Table 5 shows there are significant relationship between positive emotions with CO achievement (P<0.05). As mentioned by Row et al., (2015) Positive feelings can help students understand situations more broadly, consider possibilities, persevere through difficulties, and react appropriately to disagreement and disappointment.

Table 5. Statistical summary for the relationship between emotions and COs achievement.

Pre-Fieldwork N=61				
Feelings (I)	CO (J)	Mean Diff. (I-J)	Std. Error	Sig.
Positive	CO1	0.029	0.225	0.000
	CO2	0.025	0.311	0.000
	CO3	0.031	0.312	0.000
	CO4	0.030	0.305	0.000
Negative	CO1	-0.723	0.677	0.819
	CO2	-0.727	0.781	0.992
	CO3	-0.721	0.814	0.874
	CO4	-0.722	0.883	0.904

Post-Fieldwork N=61				
Feelings (I)	CO (J)	Mean Diff. (I-J)	Std. Error	Sig.
Positive	CO1	0.130	0.119	0.000
	CO2	0.126	0.022	0.000
	CO3	0.132	0.177	0.000
	CO4	0.131	0.208	0.000
Negative	CO1	-0.842	0.677	0.995
	CO2	-0.828	0.781	0.904
	CO3	-0.822	0.814	0.895
	CO4	-0.826	0.883	0.902

* The mean difference is significant at the 0.05 level

4. Conclusion

The study evaluated petroleum engineering undergraduate emotional experiences before and after fieldwork T&L may affect the course learning outcomes. The results indicated student perceptions about fieldwork are positive and enjoyed due to the T&L method derived effectively. Although there are a small number of students who have negative feelings before conducting fieldwork. However, after the end of the course, the negative perspective decreased. In statistical data, positive emotions have a significant relationship with learning outcomes achievement. Thus, based on the findings shown in geological fieldwork despite more challenges due to outdoor activities, students can cope and work as a team following the expectations of the program.

Acknowledgment

The authors would like to thank the Petroleum Engineering Student cohort 2019/2020 for involvement in this study and the Petroleum Engineering Department.

References

Basu, S. (2022). Effective teaching methods for engaging engineering students in geology courses. In: Proceedings of the 8th International Symposium for Engineering Education.

Cannon, S. (2018). Reservoir modeling: A practical guide. John Wiley & Sons.

Feder, J. (2019). As Industry changes, so does petroleum engineering education. Journal of Petroleum Technology, 71(12), 44-48.

Fraser, K., Ma, I., Teteris, E., Baxter, H., Wright, B., & McLaughlin, K. (2012). Emotion, cognitive load and learning outcomes during simulation training. Medical education, 46(11), 1055-1062.

Gluyas, J. G., & Swarbrick, R. E. (2021). Petroleum geoscience. John Wiley & Sons.

Huang, K. T., Robinson, L., & Cotten, S. R. (2015). Mind the emotional gap: The impact of emotional costs on student learning outcomes. In Communication and information technologies annual (Vol. 10, pp. 121-144). Emerald Group Publishing Limited

Jinn, L., C., Zaman, I. A. K., Zakaria, S., Mahali, S., & Aleng, N. A. (2022). Analyzing the Undergraduate Enrolment Pattern in Malaysian Public Universities Using Statistical Methods Journal of Mathematical Sciences and Informatics, 2(2).

Khazanah Research Institute (2023). Malaysia's gender gap in STEM education and employment. VIEWS, 6 (23).

Nyarko, S. C., & Petcovic, H. L. (2023). Do students develop teamwork skills during geoscience fieldwork? A case study of a hydrogeology field course. Journal of Geoscience Education, 71(2), 145-157.

Oaksford, M., Morris, F., Grainger, B., & Williams, J. M. G. (1996). Mood, reasoning, and central executive processes. Journal of Experimental Psychology: Learning, Memory, and Cognition, 22(2), 476.

Pan, X., Hu, B., Zhou, Z., & Feng, X. (2022). Are students happier the more they learn?–research on the influence of course progress on academic emotion in online learning. Interactive Learning Environments, 1-21.

Punch, S. (2012). Hidden struggles of fieldwork: Exploring the role and use of field diaries. Emotion, space and society, 5(2), 86-93.

Raath, S., & Golightly, A. (2017). Geography education students' experiences with a problem-based learning fieldwork activity. Journal of Geography, 116(5), 217-225.

Shahzad, A., Hassan, R., Aremu, A. Y., Hussain, A., & Lodhi, R. N. (2021). Effects of COVID-19 in E-learning on higher education institution students: the group comparison between male and female. Quality & quantity, 55, 805-826.

Stokes, A., & Boyle, A. P. (2009). The undergraduate geoscience fieldwork experience: Influencing factors and implications for learning. Field geology education: Historical perspectives and modern approaches, 461, 291.

Um, E., Plass, J. L., Hayward, E. O., & Homer, B. D. (2012). Emotional design in multimedia learning. Journal of Educational Psychology, 104(2), 485.

Zakaria, E., Chin, L. C., & Daud, M. Y. (2010). The effects of cooperative learning on students' mathematics achievement and attitude towards mathematics. Journal of Social Sciences, 6(2), 272-275.