Journal of Effective Teaching and Learning Practices. 2025; 2(1); 19-28
eISSN: 3048-9601

Enhancing Fluid Mechanics Education through a Field Trip to a Hydropower Plant

Shaharin Anwar Sulaiman[1a] and Rabi Kabir Ahmad[2]

[1] *Department of Mechanical Engineering, Universiti Teknologi PETRONAS, 32610 Bandar Seri Iskandar, Perak, Malaysia*, shaharin@utp.edu.my

[2] *Department of Agricultural and Environmental Engineering, Faculty of Engineering, Bayero University, Kano (BUK). P.M.B. 3011, Kano, Nigeria*

Abstract

A field trip to a hydropower plant can be a valuable educational experience for Mechanical Engineering students studying Fluid Mechanics, offering practical, real-world applications of classroom principles. This paper presents the key learning outcomes from a field trip to the Pergau Hydroelectric Power Station, located in the northern part of the Titiwangsa Range near the Malaysia-Thailand border. The connection between the plant's operations and fluid mechanics concepts, and how the experience enhanced students' understanding, is examined. A total of 32 students participated in the trip, completing a questionnaire on their learning experiences. The findings show that students were able to connect theoretical concepts like Bernoulli's principle, fluid flow, and energy conservation with actual engineering practices, significantly improving their grasp of hydroelectric power generation. The field trip also fostered critical thinking, problem-solving, and deeper insights into the complexities of hydropower, reinforcing the importance of fluid mechanics in sustainable energy production.

***Keywords*— Bernoulli's Principle; Experiential Learning; Fluid Mechanics; Hydroelectric Power Generation; Hydropower Plant; Sustainable Energy.**

Introduction

Fluid Mechanics, a branch of physics concerned with the mechanics of fluids and the forces on them, is a crucial subject for Mechanical Engineering bachelor students, as well as students in other related engineering disciplines. Understanding these principles is vital for designing systems and structures that involve fluid flow, such as water supply systems, sewage treatment facilities, and, most notably, hydropower plants.

Due to its abstract and mathematically intensive nature, Fluid Mechanics is a challenging subject for many students (Vaidya, 2020). The concepts often require a deep understanding of the underlying physics and the ability to visualize complex fluid behaviors, which can be difficult without strong spatial reasoning skills. Additionally, the subject involves intricate equations and principles, such as the Navier-Stokes equations and Bernoulli’s principle, which demand a solid foundation in calculus and differential equations. This complexity can make it hard for students to grasp the relationship between theoretical concepts and real-world applications, leading to difficulties in fully comprehending and applying the material. Without practical experiences or visual aids, the abstract nature of fluid mechanics can seem overwhelming, making it one of the more difficult subjects in engineering education.

Students can enhance their understanding of fluid mechanics outside the classroom by engaging in hands-on learning experiences and utilizing various supplementary resources. Participating in lab experiments or building small-scale models allows students to observe fluid behaviors in real-time, making abstract concepts more tangible (Cimbala & Cengel, 2014). Online simulations and interactive tools provide visual representations of fluid dynamics, aiding in the comprehension of complex ideas (Fraser et al., 2007). Additionally, collaborating with peers on projects or in study groups fosters deeper discussions and different perspectives, which can clarify difficult topics (Prince, 2004). Exploring real-world applications, such as visiting hydropower plants or analyzing fluid mechanics in everyday scenarios like plumbing or weather patterns, can bridge the gap between theory and practice (Brown & Duguid, 1996). Lastly, utilizing online courses, tutorials, and textbooks that offer alternative explanations and examples can reinforce classroom learning and cater to individual learning styles (Felder & Silverman, 1988).

In this paper, the key learning outcomes from a Fluid Mechanics course are illustrated through a field trip made to the Pergau Hydroelectric Power Station in Malaysia. The visit provided students with a unique opportunity to observe the practical applications of fluid mechanics principles in a real-world setting. It is also expected that the visit increases students' interest in fluid mechanics and renewable energy sources. The effectiveness of the visit is gauged through questionnaires provided to the students after the end of the trip.Body text: 12 points completely justified Times New Roman font. The first line should be indented by 1.25 cm, except for paragraphs that come after Heading Level 1. There is a space between each paragraph. Body text: 12 points completely justified Times New Roman font. The first line should be indented by 1.25 cm, except for paragraphs that come after Heading Level 1. There is a space between each paragraph.

Overview of the Power Station

The hydropower plant, known as the Pergau Hydroelectric Power Station is located in the state of Kelantan in Malaysia, is a significant renewable energy facility that plays a crucial role in the country's electricity generation. Commissioned in 2000, the underground power station harnesses the water of the Pergau River to generate electricity. The facility is part of a larger hydroelectric project that includes the construction of the Pergau Dam, a 75-meter high earth-filled dam that creates a large reservoir used to store water (Sidek, 2021). The net head is 495 m and the plant is equipped with four GE Francis turbines, each with a capacity of 150 MW (Power Technology, 2024).

The power station operates by channeling water from the reservoir through a series of penstocks to turbines, which convert the kinetic energy of the flowing water into mechanical energy. This mechanical energy is then transformed into electrical energy by generators. The Pergau Hydropower Station is an example of how natural resources can be utilized sustainably to meet energy demands while minimizing environmental impact.

In addition to its role in power generation, the Pergau project also contributes to flood control and water supply management in the region (Sidek, 2021). The project has had a significant impact on the local economy by providing jobs and contributing to infrastructure development. The Pergau Hydropower Station is not only a key component of Malaysia's energy strategy but also a valuable educational resource, demonstrating the practical application of fluid mechanics and engineering principles in the field of renewable energy.

Students and the Travel Arrangement

The field trip to the Pergau Hydropower Plant involved a group of 32 Mechanical Engineering undergraduate students, primarily in their second year of study. Among the group, six were female students, reflecting a growing but still underrepresented demographic in the engineering field. The cohort also included one international student, adding a layer of diversity to the group. The visit, which was held on 11 July 2024, provided these students with a valuable opportunity to see firsthand the application of fluid mechanics in a real-world setting, reinforcing their classroom learning with practical insights into the operation of a large-scale engineering project. This experience was particularly beneficial for these students at this stage in their education, as they were able to directly connect theoretical concepts from their studies with the complexities of hydropower generation.

The hydropower plant was located over 250 km away from the university via the winding road of East-West Highway, which took more than six hours to reach by bus. Since the host company would only allow the visit to be conducted in the morning, the students were required to stay overnight at a nearby hotel. On the positive side, such arrangement would give the participants ample time to recuperate from the long and tiring journey. They came for the visit on the next day fresh. One challenge faced during this trip was the relatively late notification given by the host, resulting in the inability of the team in securing in-house transportation, which would be far cheaper than the outsourced bus.

Fluid Mechanics Concepts Relevant to the Visit

The hydropower plant was chosen for the visit because it had many important features that the students could benefit from in enhancing their understanding of the Fluid Mechanics concepts learned in classroom. Several fluid mechanics principles that could be observed and studied from the visit were:

1. *Bernoulli's Principle*: This principle, which relates the speed of a fluid to its pressure, could be observed in the penstock as water accelerates and its pressure changes.
2. *Continuity Equation*: The principle of conservation of mass, where the flow rate must remain constant from the intake to the turbine, would be demonstrated in the penstock.
3. *Energy Conservation*: The conversion of potential energy in the reservoir to kinetic energy in the penstock and finally to mechanical energy in the turbine.
4. *Turbulent Flow Patterns*: Observation of turbulent flow patterns, which could enhance understanding of fluid dynamics.

5. *Hydrodynamic Forces*: Understanding the forces exerted by water on the turbine blades and other components of the plant.

There were also other hydropower plants within the region that the students could visit. However, most of them were previously visited by past students from the same university. The Pergau hydropower station was never visited, and it had a few special criteria that made it unique than other power plants.

In addition to the technical aspects of Fluid Mechanics, the students could also benefit enhanced learning by seeing the real-life application of subject, leading to better understanding and retention of complex concepts. Furthermore, they could also engage in problem-solving and critical thinking as they analyze the design and operation of the plant. The trip also provided an opportunity to understand the interplay between different engineering disciplines, such as civil, mechanical, and electrical engineering.

Survey on Effectiveness of Visit

A set of questionnaires was given to the participating students to obtain their feedbacks pertaining to the effectiveness of the visit in enhancing their learning on the subject. The questionnaires were prepared in Google Form. The respondents were asked nine questions, which are listed in Table 1.

Table 1: List of questions in the survey.

No	Style
1	How would you rate your overall experience of the field trip?
2	What aspects of the field trip did you find most enjoyable?
3	How much do you feel the field trip enhanced your understanding of fluid mechanics concepts?
4	Which specific fluid mechanics concepts do you feel you understood better after the field trip?
5	Did the field trip provide a clear connection between theoretical knowledge and practical application?
6	How effective were the guides/presenters in explaining the workings of the hydropower plant?
7	Were you given adequate opportunities to ask questions and interact with the plant staff?
8	How would you rate the organization of the field trip (transportation, schedule, guidance)?
9	Were the facilities at the hydropower plant adequate for a learning visit?

Findings

Although there were 32 students in the trip only 30 of them (94%) responded to the survey. The results are presented in this section. Figure 1 shows the results in term of overall experience. The survey revealed that the majority of students had a positive experience during the field trip. 80% of respondents rated their overall experience as "Good," with 16.7% rating it as "Excellent," and only 3.3% expressing a neutral opinion. This indicates a generally favorable reception of the trip.

When asked about the most enjoyable aspect of the field trip, as implied in Figure 2, 76.7% of students highlighted "Exploring the hydropower plant" as the key highlight. Another 16.7%

found "Observing practical applications" most enjoyable, while only 6.6% cited "Learning new concepts" as their top choice. This suggests that hands-on, real-world exposure was the primary draw for most students.

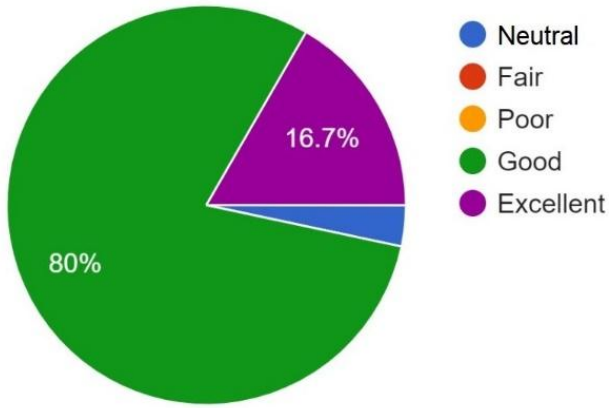

Figure 1: Rating on the overall experience of the field trip

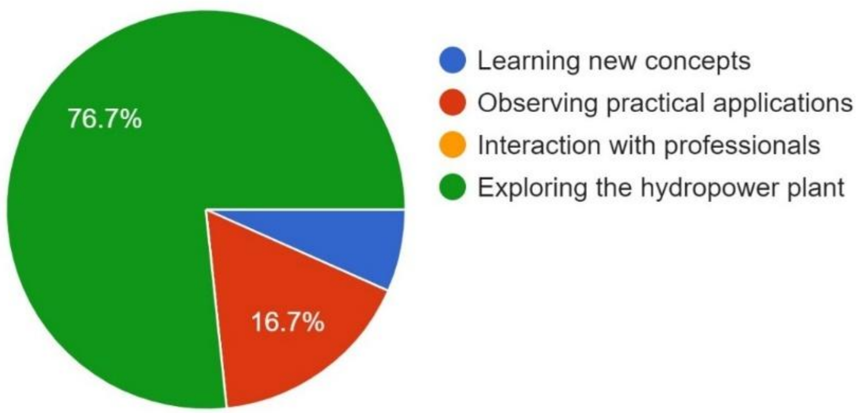

Figure 2: Aspects of the field trip that students found most enjoyable

In terms of enhancing their understanding of fluid mechanics, it is shown in Figure 3 that 20% of the students reported that the field trip significantly improved their comprehension, while 80% indicated moderate improvement. This shows that, while the trip positively impacted most students, there is room for increasing the depth of learning during such visits.

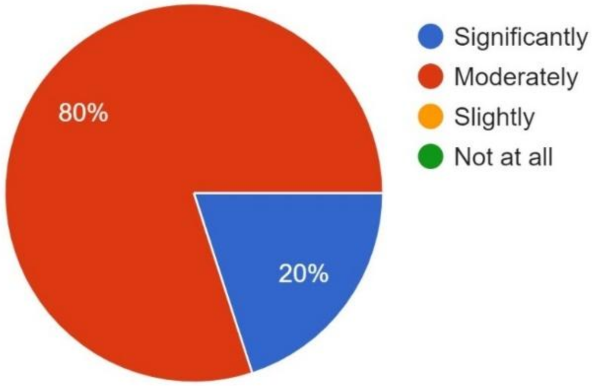

Figure 3: On the enhancement of understanding of Fluid Mechanics concepts through the field trip

A main objective of the field trip is to get the students better understood specific concepts of the fluid mechanics course. Figure 4 shows distribution of concepts that the students believed that they understood better after attending the field trip. Hydroelectric power generation emerged as the concept most clarified by the trip, with 80% of students indicating better understanding of this area. Other concepts like turbine operation (10%), flow dynamics (7%), and energy conversion (3%) were less frequently mentioned, reflecting the emphasis of the tour on the overall power generation process rather than on more detailed fluid mechanics concepts.

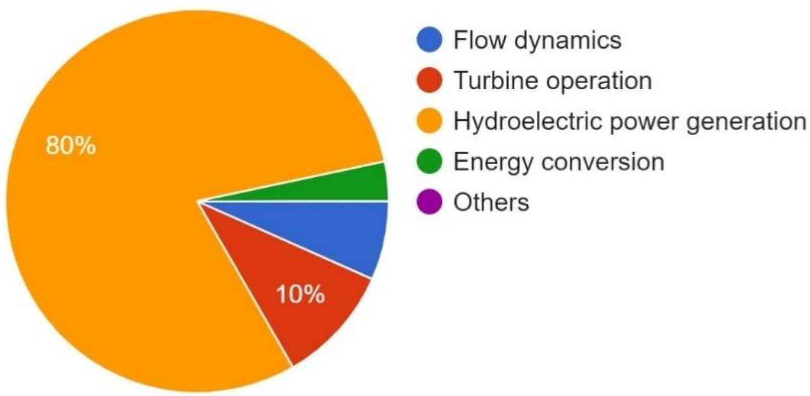

Figure 4: Specific Fluid Mechanics concepts that the students felt that they understood better from the field trip

Shown in Figure 5 is the distribution of responses pertaining to the connection between theoretical knowledge and practical application recognized from the field trip. A large majority of students (83.3%) felt the trip provided a "Somewhat clear" connection between theoretical knowledge and practical applications, while 16.7% found the connection "Very clear." This suggests that the field trip was successful in demonstrating the practical relevance of classroom theories, though further clarity could be achieved in future trips.

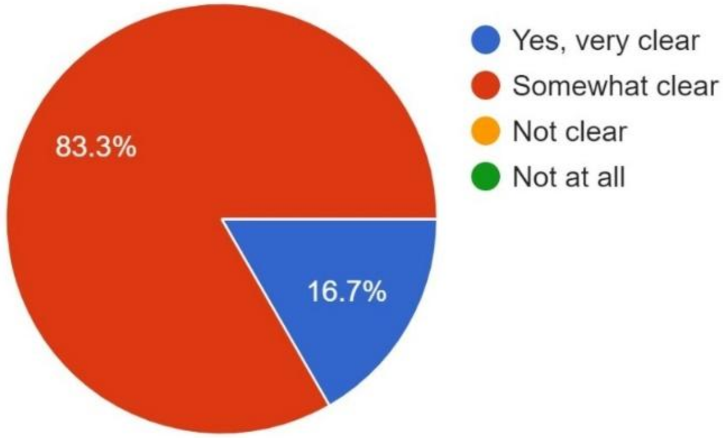

Figure 5: On the connection between theoretical knowledge and practical application recognized from the field trip

The guidance provided during the field trip was rated highly by the students, with 83.3% finding the guides "Effective" and 16.7% considering them "Very effective," as implied in Figure 6. This reflects the strong communication skills of the staff in explaining the workings of the plant.

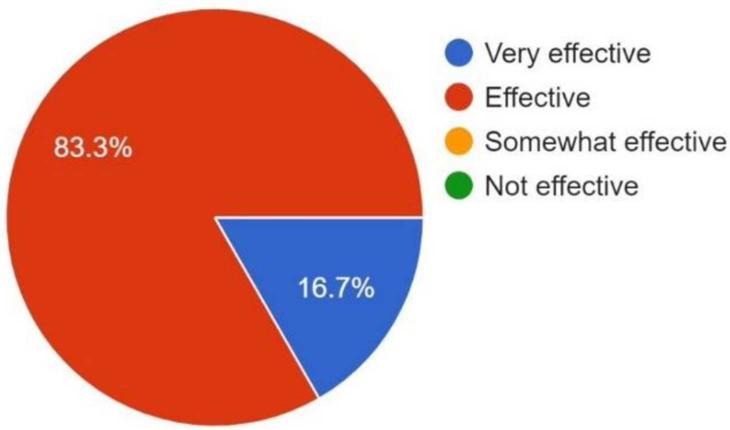

Figure 6: The effectiveness of the host's guides and presenters in explaining the design and operation of the hydropower plant

When it came to student interaction with the plant staff, 80% felt they had "some opportunities" to ask questions, while 20% reported "plenty of opportunities," as depicted in Figure 7. This indicates a generally interactive environment, although there may be room to increase engagement.

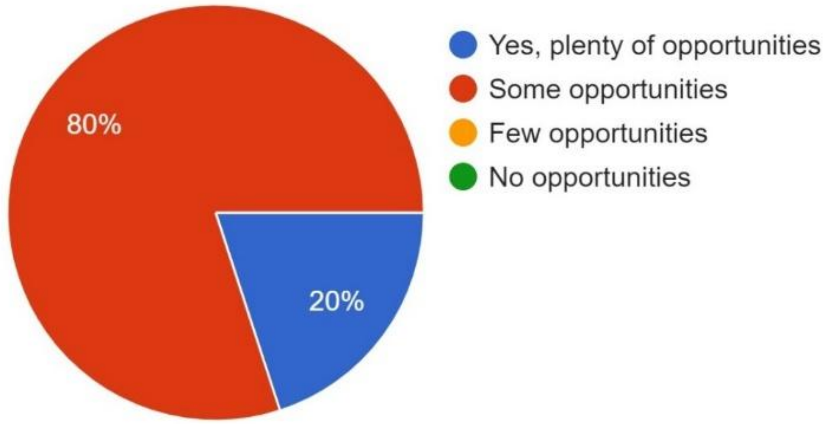

Figure 7: On the adequacy of opportunities to interact and to ask questions to the plant staff

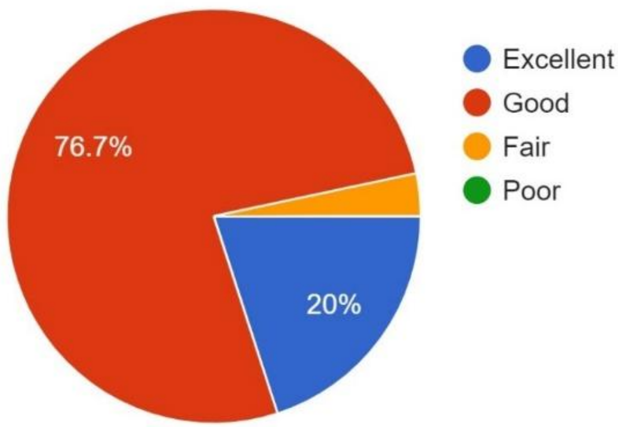

Figure 8: Rating on the organization of the field trip

The organization of the field trip was an important element in ensuring the success and effectiveness of the program. As shown in Figure 8 the trip's organization was rated positively, with 76.7% of students describing it as "Good" and 20% as "Excellent." Only 3.3% rated it as "Fair," highlighting that logistical arrangements such as transportation and scheduling were well-managed overall.

In terms of the facilities provided at the hydropower plant, 73.3% of students rated them as "Adequate" and 26.7% as "Very adequate," as depicted in Figure 9. This suggests that the plant provided a conducive learning environment, but there may be areas for improvement in terms of offering more specialized facilities or resources for educational visits.

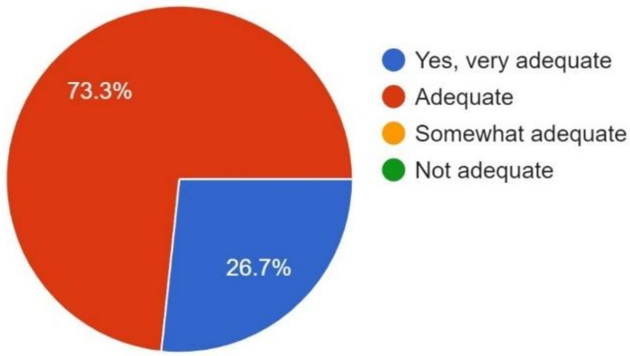

Figure 9: On the adequacy of the plant facilities in relation to the learning visit

Conclusion

The field trip to the Pergau Hydropower Plant was well-received by students, who particularly appreciated the opportunity to explore the plant and observe practical applications of fluid mechanics. The trip moderately enhanced their understanding of the subject, especially in the area of hydroelectric power generation. While the organization and guidance were rated highly, there are opportunities to further improve student interaction and the connection between theory and practice in future visits. Such experiences are invaluable in fostering a more profound interest in fluid mechanics and encouraging students to pursue careers in fields related to renewable energy and sustainable engineering practices. By integrating field trips into the curriculum, educators can provide a holistic and enriching learning experience that prepares students for future engineering challenges.

From the survey, it is also recommended that the following issues be addressed in advanced prior to trip:

a. Pre-Trip Preparation: Students should be briefed on the basic operations of a hydropower plant and the fluid mechanics concepts they will observe.
b. Interactive Sessions: Include interactive sessions with plant engineers to provide insights into the challenges and innovations in hydropower technology.
c. Post-Trip Activities: Assign projects or presentations to allow students to reflect on their experiences and relate them to their coursework.

Author Bio

Shaharin Anwar Sulaiman is a professor in the Department of Mechanical Engineering, Universiti Teknologi PETRONAS, 32610 Bandar Seri Iskandar, Perak, Malaysia. He holds a B.Sc, M.Sc, and Ph.D. in Mechanical Engineering from the USA and the UK. He was an M&E Engineer in YTL Construction prior to joining the academics in 1998. He served as a Director for Hybrid Energy Systems in UTP from 2009 to 2017. His research interests include air-conditioning, biomass energy, solar photovoltaic, combustion, and flow assurance. He has published 12 books, 223 journal articles and more than 155 papers in conference proceedings. Presently, he is Chief Editor of UTP's journal (Platform: A Journal of Engineering). shaharin@utp.edu.my

Rabi Kabir Ahmad is a Senior Lecturer in the Department of Agricultural and Environmental Engineering at Bayero University Kano, Nigeria. She earned her B.Eng. and M.Eng. degrees from Bayero University Kano and obtained her Ph.D. from Universiti Teknologi Petronas, Malaysia. She joined Bayero University Kano in 2012. Her research interests include biomass conversion to fuel, processing and storage engineering, as well as farm power and machinery engineering. She has authored six book chapters and published over 30 journal articles and conference papers.
rkahmad.age@buk.edu.ng

References

Brown, J. S., & Duguid, P. (1996). Stolen knowledge. In H. McLellan (Ed.), *Educational technology publications* (pp. 47-56). Englewood Cliffs, NJ: Bergen.

Çengel, Y. A., & Cimbala, J. M. (2014). *Fluid mechanics: Fundamentals and applications* (3rd ed.). McGraw-Hill.

Felder, R. M., & Silverman, L. K. (1988). Learning and teaching styles in engineering education. *Engineering Education, 78*, 674-681.

Fraser, D. M., Pillay, R., Tjatindi, L., & Case, J. M. (2007). Enhancing the learning of fluid mechanics using computer simulations. *Journal of Engineering Education*, *96*, 381-388.

Power Technology. (2024). Power plant profile: Pergau, Malaysia. *Power Technology*. Retrieved August 21, 2024, from https://www.power-technology.com/data-insights/power-plant-profile-pergau-malaysia/

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education, 93*, 223-231.

Sidek, L. M., Yalit, M., Djuladi, D., & Mohammad, M. (2021). Flood damage assessment for Pergau Hydroelectric Power Project using HEC-FIA. *IOP Conference Series: Earth and Environmental Science, 704*, 012002. https://doi.org/10.1088/1755-1315/704/1/012002

Vaidya, A. (2020). Teaching and learning of fluid mechanics. *Fluids, 5*(49). https://doi.org/10.3390/fluids5020049