Expanding horizons: The pedagogical benefits of museum visits for engineering students

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Abstract

This paper explores the pedagogical benefits of a museum visit for engineering students. While field trips have proven to be effective tools to improve students' critical thinking, ethical reflection, and cultural awareness, they are still rarely featured in engineering curricula. This paper focuses on a field trip to a museum as part of the course 'International Engineering: From Hubris to Hope' at ETH Zürich, where students explored an exhibition addressing colonialism and looted art. We show how this experience bridges the gap between technical knowledge and the complex contexts that engineers must navigate during their career. Combining student questionnaires and reflective reports, we find that students strongly appreciate this type of experiential learning. Moreover, interviews with different stakeholders highlight the importance of field trips in fostering deeper engagement and critical thinking. Overall, our findings suggest that this type of project-based learning can enhance engineering students' preparedness for the ethical and cultural challenges they will encounter in their professional careers.

Introduction

In engineering education, the focus has traditionally been on conveying technical knowledge and honing problem-solving skills through 'chalk and talk' (Rugarcia et al., 2000; Shuman et al., 2002; Rosen, 2009). While direct teacher instruction remains an important pedagogical tool, it often falls short of conveying the complexities of the real world. More than ever, engineers must have a well-founded understanding of the cultural and social phenomena with which technology interacts outside the classroom. The course 'International Engineering: From Hubris to Hope' at ETH Zürich addresses this need by integrating ethical reflection and cultural understanding in its curriculum through project-based learning. Through debates, interactive panels, and, as highlighted in this paper, a field trip, the course introduces students to issues such as colonialism and cultural appropriation and the implications for students' careers. This novel approach intends to prepare engineers for working contexts where their decisions and actions can have profound ethical and cultural consequences.

Despite positive trends, most engineering programs lack practical training in skills like critical thinking and cultural empathy. Undergraduate curricula are often saturated with courses focused on direct instruction methods, resulting in few opportunities for learning experiences outside the classroom. For instance, at ETH Zürich, our home institution, students must complete a minimum of 6 ECTS credits in Science in Perspective to 'understand and critically question the correlations between scientific knowledge, technological innovations, cultural contexts, individuals and society (D-MAVT, 2025).' These credits account for only 3% of the total required credits.

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Yet, studies show that integrating different teaching methods can significantly enhance learning outcomes for engineers (Lavado-Anguera et al., 2024). Building on these insights, 'Hubris to Hope' features a project-based learning approach to get students out of the classroom, into the real world. For last year's iteration of the course, the class visited the exhibition 'Pathways of Art: How Objects Get to the Museum' at the Museum Rietberg, where students engaged with exhibits that highlight issues of colonialism and cultural appropriation through the lens of the Benin Bronzes.[2] The project required students, following their visit, to contextualize the topics of art theft and neocolonialism in a worksheet. This reflective exercise aimed to foster a deeper understanding among students of the ongoing consequences of these historical events and their continuing impact on the engineering profession.

Using a mixed-method approach, we aim to answer the following research question: *How can experiential learning methods in the form of a field trip enhance learning outcomes of engineering students and deepen their understanding of complex social issues?* Our methods include questionnaires for students and interviews with both lecturers and the museum's curator to assess the relevance and impact of this type of experiential learning. The goal is to demonstrate the educational value of field trips and their benefits not only for knowledge retention but also regarding social and personal skills. By doing so, we aim to contribute to the ongoing discussion about how to best prepare engineering students for the ethical challenges they will face in their professional lives. Our results indicate that students are not only open to the idea but actively desire more opportunities for project-based, real-world tasks that extend beyond the classroom.

Literature review

Field trips have long been recognized as valuable educational tools (Behrendt & Franklin, 2014; Ramachandiran & Dhanapal, 2016). Underlying this pedagogical tool is the concept of experiential learning, defined as the process 'whereby knowledge is created through the transformation of experience (Kolb, 2015, p. 49).' By engaging students in experiences outside the classroom, abstract concepts become tangible and allow students to experience them in the real world. Through learning by doing, bridging the gap between theoretical knowledge and practical application, field trips provide students with hands-on, immersive experiences and have proven to enhance cognitive learning, increase student engagement, and promote personal development (Behrendt & Franklin, 2014; Falk & Balling, 1982).

Only a few studies have evaluated the benefits of field trips on engineering students' learning outcome. Those who did focused mostly on their impact on knowledge retention and practical application. For instance, evaluating the benefits of field trips in construction management courses, Salman (2023) has shown that they provide tactile experiences and real-time professional interactions, which are crucial for a comprehensive learning experience. In another study including industrial engineering students, Townsend and Urbanic (2013) show that field trips result in high student engagement, deep learning (e.g., 42% of the students noticed significant change in their attitudes and beliefs about manufacturing) and the improved ability to relate personal experiences to the field trip.

However, while these studies highlight the benefits of field trips, they do not address to which extent field trips encourage ethical reflection. Although students may internalize some ethical considerations through immersive and emotional learning, understanding how these ethical reflections arise and can be actively encouraged is important. As mentioned earlier, graduates entering international work environments are likely to encounter issues such as white saviorism and cultural appropriation at some point in their career. Being able to critically assess these situations plays a significant role in addressing and changing the underlying mechanisms.

[2] These plaques and sculptures, generally known as the Benin Bronzes, were made by the Edo people of the Kingdom of Benin, located in modern-day Nigeria (Kiwara-Wilson, 2012). Looted by British forces in 1897, the Bronzes are celebrated for their historical significance and representation of Benin's rich cultural heritage.

Research on how museum visits promote ethical reflections in university students is limited, but insights from lower grades provide some understanding. In their large-scale study, where the randomly assigned treatment consisted of a one-hour museum tour, Green et al. (2014) find that students in the treatment group improved their critical thinking by an average of 9 percent of a standard deviation compared to the control group, operationalizing critical thinking as ability to interpret works and their historical context.

Although their focuses on critical thinking regarding art and its historical context, it opens the door to exploring how museum visits can also promote ethical reflections in visitors. The concept of historical empathy helps to understand some of the underlying mechanisms. Defined as 'the process of students' cognitive and affective engagement with historical figures to better understand and contextualize their lived experiences, decisions, or actions', historical empathy is a key driver behind ethical reflection (Endacott & Brooks, 2013, p. 41). Studying an exhibition on children living through World War II, Savenije and De Bruin (2017) find that even though visiting students did not have a personal connection to these historical events, most were emotionally engaged through the display of objects and the exhibition's focus on personal stories. Smith (2016) observed similar outcomes, with students showing emotional engagement after visiting an exhibition on the British slave trade.

Gammon (2003) provides further insights in his guide 'Assessing Learning in Museum Environments', detailing the learning processes that occur during a museum visit. He identifies five indicators: cognitive, affective, skill-based, social, and personal learning. Cognitive learning involves visitors consolidating their knowledge and connecting it with experiences or knowledge from other areas. This is a key reason why museum visits are part of the 'Hubris to Hope' curriculum. Affective learning, in turn, is closely related to historical empathy. Exhibits and interactive elements challenge visitors' beliefs, fostering empathy or at least an understanding of different perspectives and values. A museum visit is also a social experience. Students get to know each other better and interact with lecturers outside the classroom, which can lead to more cooperation. Finally, the field trip equips students with new skills. The assignment, in our case a report on the experience, is designed to enhance their critical reflection and writing skills, boosting self-efficacy and personal learning as described by Gammon (2003).

Against this backdrop, our paper seeks to explore how a museum visit can promote not only cognitive learning but actively encourage critical thinking and ethical reflection for engineering students. By involving them in immersive and interactive tasks during the trip, this paper aims to provide new insights into leveraging the educational impact of field trips when it comes to preparing future engineers for the ethical and practical challenges they will face in their careers.

Case study: Field trip to Museum Rietberg

The course 'International Engineering: From Hubris to Hope' offers a novel approach to engineering education by combining technical knowledge with ethical reflection. It challenges students, mostly from engineering backgrounds, to think about the broader impact of their work in a global context, especially regarding the ethical responsibilities that come with engineering in a connected world. The course focuses on understanding historical and cultural contexts and reflects on the engineering profession through a global and sociopolitical perspective.

Project-based learning as a pillar of the course

The course aims to promote ethical reflection through several project-based learning approaches, such as debates, flipped classrooms and student presentations. For example, students are asked to find out how to apply for an engineering degree at an African university and share their experience in a presentation with the class. The goal of this hands-on learning approach is to let students experience firsthand the bureaucratic obstacles often encountered when applying for programs or grants. In another assignment, students chose a Sustainable

Development Goal (SDG) and, using a flipped classroom format, presented the flaws and challenges in measuring their selected indicator.

A museum field trip is another project-based component of the course. The city of Zurich hosts several museums that offer exhibitions on course-relevant concepts such as decolonization or the exploitation of natural resources. The Museum Rietberg is known for its collection of art and artifacts from different centuries and regions around the world. Its exhibitions often raise important questions about the origins of the displayed items, many of which are linked to histories of colonialism and cultural appropriation. The museum's 'Pathways of Art: How Objects Get to the Museum' exhibition, along with its visual storage collection, were the focus of the students' visit (Museum Rietberg, 2024). These exhibitions provide a valuable context for students to engage with the ethical dilemmas related to the acquisition and display of cultural artifacts, encouraging them to critically examine Switzerland's role in colonial history and its ongoing impact on global power structures.

Assignment to encourage reflection during field trip

To deepen the student's engagement with the ethical questions raised by the museum's collection, we gave students an assignment prompting them to reflect on their experience. The assignment had two parts, each requiring students to engage critically with the exhibited objects and how they are presented.

In the first part, students chose three objects from different stations within the exhibition. They had to give a brief description of each object, including its history, and consider how both the collectors and creators were represented in the museum's narrative. Students were encouraged to critique the museum's role in acquiring these items, questioning whether the displays accurately and ethically told the story of their acquisition. They also had to identify any missing information and suggest improvements, such as changes to the display text or even the relocation of the objects. Importantly, students were asked to consider whether the objects should be returned to their places of origin.

The second part of the assignment focused on a culturally or religiously significant item from the museum's visual storage collection. Students had to describe how the item was displayed and evaluate whether the display increased or decreased its significance. They reflected on how the original owner or creator might feel about the current display and proposed alternative display methods or ways to return the item to ensure a more just presentation.

Methods

We evaluated the impact and potential benefits of this assignment using a three-step process. First, we asked students to complete a questionnaire that included a mix of multiple-choice and open-ended questions, along with demographic information such as age, academic background, and previous experience. This helped us understand the impact of the field trip on them. Additionally, we wanted to see how students' perceptions of the assignment would change if they knew their reports would be shared with the museum. We asked whether they felt they would have gained something from such an interaction and how they might have approached the assignment differently. Finally, we asked all students if they were willing to share their reports with the museum's directorate. From those who agreed, we collected recurring themes and suggestions for improving the museum's exhibitions, reviewed and corrected them for grammar, and shared a summary with the museum's curator.

Second, we conducted interviews with the two course lecturers to get their views on how effective the field trip was as a teaching tool. These interviews were intended to provide a complete view of how the field trip fits into the overall goals of the course and its impact on student learning. We asked them about their experiences organizing field trips, the impact these trips had on students in their opinion, and their impression on the value of having students submit their reports to the museum.

Third, we conducted an interview with the museum's curator to understand the museum's perspective. We explored her views on the educational value of such field trips, her willingness to engage directly with students, and her openness to including student feedback in the museum's practices as well as read and respond to the student reports. Collecting the museum's feedback was important to know whether it would be possible to make the field trip more interactive by having direct interaction between students and the museum staff during the trip.

Results

Our sample consisted of 23 undergraduate and graduate students, representing around 65% of the course participants. Most of them studied at the Department of Mechanical and Process Engineering (D-MAVT). On average, they were 24.3 years old and had spent 4.1 years at ETH Zurich. As shown in Table A1, students had participated in less than one (0.9) field trip during their studies, highlighting the low prevalence of this pedagogical tool in their study programs.

Overall, students rated the field trip very positively with an average score of 4.04 out of 5 (see Table A2). Most of them found the experience educational and meaningful. The assignment was rated almost equally favorably with an average score of 3.70 out of 5. The slightly lower score might suggest that students appreciated the experience but would have preferred a more structured assignment. On the other hand, the desire for more project-based assignments was strong. The average rating of 4.36 out of 5 underscores the value students place on activities that feel connected to real-world impact.

78% of the students expressed that they would have liked to see the impact of sending their reports to the museum while only 30% believed that they would personally benefit from it. This distinction could highlight the desire to contribute to something meaningful while expecting no to little personal gain from such a contribution. When asked if they would have done something differently if they had known that the reports would be sent to the museum, 65% of the students answered with 'Yes'. With more at stake, this highlights the potential to further encourage students when they know their work will not only be theoretical but also shared with stakeholders or experts. Lastly, almost all students (91%) believed that no specific degree level was necessary for ETH students to engage with external institutions, suggesting confidence in their ability to contribute meaningfully regardless of their academic status.

Below we list a few selected written statements from students to further illustrate their experience and their hopes and expectations for future field trips.[3] Many students expressed a strong desire for experiential learning and opportunities to interact with professionals in their field.

'[Sending our reports] would give our work a purpose and it would make us think more about the way we would write things in the report.'

'[Sending our reports] would provoke a reaction. Even if the museum does not do anything about the criticism, we still learn more about the museum.'

'I wish we had more chances to do projects with stakeholders outside of academia. Where you get real feedback and can work with motivated people.'

These results reflect an enriching experience for most of the students. A large majority rated both the visit and the assignment positively, even though only a few believed their reports would actually make a difference. In this regard, there is still potential to enhance the pedagogical benefits of such trips. As noted in the students' comments, a more tangible output

[3] The feedback was overall very positive. Only one student expressed low confidence in the abilities of students to inform the museum.

could provide a stronger sense of purpose and, consequently, increase student engagement. The survey data confirmed this: nearly two-thirds would have approached the assignment differently if they had known in advance that their work would be shared.

Lecturer observations

To provide more context for the quantitative findings, we interviewed the two course lecturers. Both highlighted the significance of the museum trip, noting that it offered a valuable chance to engage with course material in a more dynamic way outside the classroom. In their opinion, taking students on a field trip fosters different conversations and perspectives, making the learning experience more fun, active and social.

They also observed that students tend to be more engaged and participative not only during but also after a field trip. According to the lecturers, the experience helps students connect theoretical concepts to real-world situations, making their learning more relevant and memorable. In the weeks after the field trip, one lecturer mentioned that students were more likely to bring up examples from the field trip than from the literature during the lectures.

'I find that when you look at their writing and we look at their exams, they draw on those experiences more than they do on the readings.'

Moreover, the lecturers noted that the field trip actively fostered critical thinking. After the trip, students demonstrated a noticeable shift from abstract understanding to using concrete examples in their analyses and critiques. This change was marked by a deeper, more grounded reflection as they began to reflect more on their backgrounds and experiences, often sharing personal stories that enriched class discussions.

There was also a social benefit to the field trip. After the museum visit, social interaction and class dynamics became livelier. The informal setting helped break down barriers between both students and lecturers, fostering a more relaxed and open atmosphere. Students could interact with their lecturers and peers outside the classroom, enhancing the overall learning environment. As one lecturer put it:

'I think the classroom is a limited learning space, and when you go outside the classroom, you open that up. Having a conversation with the students and amongst the students in a different space is also important.'

However, the lecturers also mentioned challenges and improvements needed for future field trips. Both emphasized the importance of a well-structured trip. This resonates with the findings from Lee (2020) who found a positive association between student outcomes and pre-visit preparation and post-visit activities. They considered involving museum staff to enhance the learning experience, though they recognized this might present challenges. One lecturer remarked that while students would likely benefit greatly from such interactions and improve important skills, it would entail extensive planning for the teachers, a challenge also mentioned by Salman (2023).

Museum interview

Lastly, we interviewed the museum's curator for the Africa and Oceania sections, Michaela Oberhofer, to gain insight into the museum's perspective. Before the interview, we had sent her a curated compilation of student letters. After reviewing them, she acknowledged that while the students clearly demonstrated critical thinking, there was still room for improvement. To close this gap, she suggested a more in-depth exchange, something that was also requested by the students, to make the students' analysis more substantial. Oberhofer was also open to join the class to discuss the political and ethical challenges surrounding the museum's collection. Lastly, she proposed a more structured process to the museum visit: Students could first visit the museum at their own pace and write the report based on their visit. Once

submitted, the students would participate in a follow-up discussion with museum staff, allowing for deeper reflection and giving students the opportunity to engage in a more comprehensive dialogue about the ethical, political, and cultural considerations behind the museum's practices.

Discussion

Our results show that students appreciate the opportunity to engage with the subject matter through immersive experiences. The survey feedback was overall positive, with students expressing a strong interest for more interactions during the visit. This enthusiasm was echoed in the qualitative feedback, where both lecturers and the museum's curator highlighted the value of these interactions in fostering a deeper understanding of the complex social and cultural issues surrounding the artwork exposed.

The feedback from lecturers reinforced the importance of integrating more immersive experiences into the engineering curriculum. They observed that students became more engaged and demonstrated a deeper level of critical thinking after the museum visit. They also noted that students were more likely to draw on real-life examples in their discussions and assignments, which helped them connect theoretical concepts to tangible experiences. This shift from abstract to concrete thinking is particularly important as engineering students tend to focus on technical problem-solving at the expense of soft skills (Caratozzolo et al., 2019).
Despite the promising results, we acknowledge a few limitations. First, the dataset is small, with responses collected from a limited number of students specific to one course at ETH Zurich. This limits somewhat the generalizability of our findings to other contexts. We suggest that future research should involve a more extensive and diverse group of subjects to explore the opportunities of field trips across a wider range of courses and institutions.
We are also aware that the COVID pandemic made most field visits impossible, resulting in the limited experience of students in this regard. Therefore, our results may not fully represent the broader population of engineering students or other educational settings where field trips are an essential part of the curriculum.

Conclusion

This study aimed to demonstrate that bringing students away from their textbooks into the real-world has the potential to foster critical thinking in engineering students. The positive reception from both students and lecturers underscores the value of the field trip, particularly in fostering deeper learning and ethical, social and cultural understanding. However, the findings also highlight the importance of carefully structuring assignments to ensure they are both impactful and meaningful to students. While this study's scope is limited to one course, the results suggest that integrating more real-world tasks into engineering curricula could better prepare students for the ethical and cultural challenges they will face in their professional lives.

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AI Tool	Use Case	Scope	Example Prompt
Microsoft Copilot (through ETH) *Last date of access: 20.02.2025*	Linguistic improvements	Whole paper	'Make this sound more natural.' 'Rephrase this sentence. Give me five alternatives.' 'The wording is off here, the transition between the paragraphs is too rough. Can you give me some leads?' 'Give me ten alternative titles for this one: Beyond the Books: The Pedagogical Benefits of Taking Mechanical Engineers to a Museum'
Perplexity (free tier) *Last date of access: 20.02.2025*	Finding papers	Literature Review	'Studies showing how museum visits encourage ethical reflection in students.'
Scopus AI (through ETH) *Last date of access: 20.02.2025*	Finding papers	Literature Review	'Studies showing how museum visits encourage ethical reflection in students.'

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Appendix

Question	Unit	Average
Age	Years	24.3
Years at ETH	Years	4.1
Number of previous field trips	Field Trips	0.9

Table A1: Survey Demographics.

Question	Unit	Average
How would you rate the visit to the Rietberg Museum as part of the course? (1: I learned nothing, 5: I learned a lot)	Likert	4.04
How would you rate the assignment (report)? (1: I learned nothing, 5: I learned a lot)	Likert	3.70
Would you enjoy more task-based assignments? (1: Not at all, 5: Very much)	Likert	4.36
Would you have liked the potential impact of actually sending the report?	% Yes	78
Would you have profited from the potential impact?	% Yes	30
Would you have done something differently if you had known the reports would be sent during the semester?	% Yes	65
What level of degree do you think is necessary for ETH students to be qualified to engage with members from other institutions/government?	% said no degree	91

Table A2: Survey Responses.