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Embedding Cultural Aspects in Engineering and Construction Education

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ABSTRACT

CONTEXT

One of the common graduate attributes of tertiary students involve appreciation of the societal and cultural issues and the consequent responsibilities. In New Zealand and some other commonwealth countries, cultural considerations would include two dimensions of bi-culturalisms and multiculturalism concepts.

PURPOSE OR GOAL

In recent years, university class compositions usually consist of students who come from significantly diverse cultural groups. Review of literature shows that even though there are some studies on integration of cultural concepts in teaching, but there are still limited works on practical methods for incorporating cultural concepts in the context of engineering and construction. In this paper, a case study of integrating the cultural aspects in a particular engineering course is discussed.

APPROACH OR METHODOLOGY/METHODS

The integration of cultural aspects in teaching can be approached through several methods. In this case study, the focus is to incorporate discussions and examples from diverse cultural contexts relevant to engineering and construction practices. The cultural concepts were incorporated in the teaching contents, class activities and within a course assignment/project.

ACTUAL OR ANTICIPATED OUTCOMES

The outcomes and lessons learned from this experience are discussed through the authors' autoethnographic reflection. The students generally engaged well in the class and in the project. They investigated various traditional buildings or historical engineering/construction techniques from different cultures and communities including Māori case studies.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

The practical examples of cultural/traditional engineering and construction cases discussed here can be used by educators and can be potentially integrated in teaching relevant engineering or construction courses. The students' projects and their findings and reflections highlighted the fact that engineering and construction, like many other fields, have always been a collective human endeavour shaped by diverse cultural contributions. This realization would not only enhance the students' cultural awareness, motivation and sense of connection with engineering but also highlights how sustainability and cultural significance can inspire innovative practices in engineering and construction.

KEYWORDS

Cultural integration, Engineering Education, Construction Education

Introduction

The importance of 'graduate attributes' and how they can be incorporated into engineering curricula are discussed frequently, however, possible methods for effective incorporation of some of attributes, particularly the cultural competence remain understudied. For example, both Sydney and Washington accords refer to cultural aspects under "Design/development of solutions" and under "The engineer and society" graduate attributes (International Engineering Alliance, 2021). These include solving of engineering problems which can consider specific cultural, societal and environmental considerations, and the use of reasoning informed by contextual knowledge to assist in societal, legal and cultural issues impacting on engineering problems. Additionally, cultural competence is becoming more and more important for modern day jobs (Poli et al., 2022) and many companies and organisations are keen to build cultural intelligence in engineering graduates.

There have been many efforts over the years to investigate methods for integrating cultural aspects or to highlight the importance of incorporating cultural aspect in tertiary studies. The integration of cultural aspects can be approached through several methods. Goldfinch et al. (2010) reported a project aimed at improving cultural intelligence among first-year engineering students at the University of Wollongong. It highlights the limited focus on cultural awareness in engineering curricula despite the globalized nature of the engineering workforce. The project developed a series of tutorials that integrate cultural awareness with engineering design, using examples like the Engineers Without Borders Challenge and Indigenous Australian perspectives.

Rhamdhani et al. (2009) explored how engineering students at Swinburne University of Technology, both in Australia and Malaysia, are being prepared for culturally diverse work environments. It highlights the need for graduates to function in international and multicultural settings. The paper concludes by proposing a pilot project to enhance intercultural engagement through a group project in the Heat Transfer unit, where students will work together on problems that emphasize cultural awareness and collaboration.

Embedding Indigenous perspectives and pedagogies into the curriculum acknowledges and integrates the knowledge and cultural practices of native communities. This approach was reported to create a more inclusive and culturally aware educational environment (Williamson & Dalal, 2007). Another method is to use narratives and storytelling to promote cultural inclusiveness and give voice to minority perspectives. This method was also shown to enhance cultural understanding and empathy among students (Daddow et al., 2021).

Wilson et al. (2015) reported that feelings of belonging (especially belonging in a particular course) were associated with positive emotional and behavioural engagement in STEM college students. Feeling that engineers do things that "people like me do" was a powerful motivation to choose, and complete an engineering major (Matusovich et al., 2010).

Encouraging collaborative projects that involve students from different cultural backgrounds would be also beneficial. This promotes cross-cultural interaction and learning through practical, team-based activities (Mak et al., 2014). It is also useful to utilize culturally responsive teaching methods to engage students from diverse backgrounds. This includes adapting teaching styles to meet the cultural needs of students (Parrish & Linder-VanBerschot, 2010).

In the New Zealand context, Hughes et al. 2017, reported a collaborative project between final-year engineering students at the University of Canterbury and the Koukourārata Māori community. The project aimed to develop sustainable engineering solutions for water, sanitation, and land use issues, incorporating the Māori worldview into the design process. The study highlights the importance of integrating indigenous perspectives into engineering education and practice. In New Zealand, there are two key dynamics coexisting, firstly there is, the relationship between the cultures of Anglo New Zealanders, Pakeha, and Indigenous New Zealanders, Māori and secondly, recent increase in immigration and rapid growth of various multicultural communities and the national commitment to multicultural values and principles (Smits, 2019).

A review of the literature shows that, while some studies explore the integration of cultural concepts in teaching, practical methods for incorporating these concepts within engineering and construction education remain limited. This paper presents a case study on integrating cultural aspects into a specific engineering course. The approach undertaken in this paper, emphasizes fostering a sense of belonging, as recommended in the literature, by encouraging students to reflect on their own cultural backgrounds. Through exposure to culturally relevant engineering examples, ranging from international cases to indigenous Māori concepts within the New Zealand context, the students gained insight into how engineering practices align with, and have historically reflected, the values and practices of diverse cultures, including their own.

Case study

In this case study, the cultural concepts were incorporated in an engineering professional practice course delivered at Ara Institute of Canterbury, through embedding the cultural discussions in the teaching contents, class activities and within a course assignment/project. This involved four main parts including:

- Incorporation of discussions on general cultural issues (Multicultural aspects) in the course contents, such as discussions on cultural awareness, cultural humility, and some contents on the history of engineering and construction and the contributions from various cultures.

- Incorporation of discussions on Māori cultural aspects (by a Māori expert guest lecturer). This included discussions on biculturalism in the New Zealand context, history of Māori in New Zealand, Treaty of Waitangi, Māori worldview and traditional Māori architecture/building construction forms.

- Incorporation of class activities to scaffold the students' learning in this area. For example, a class activity on investigation of traditional/natural construction materials used in various countries and another class exercise on traditional/natural construction materials used by Māori in New Zealand.

- Introducing an assignment with focus on linking the cultural aspects with engineering and construction concepts (Table 1).

The class activities were designed mostly in the form of group works blended with online resources, web-based tools and Moodle forums using Problem-based learning pedagogies (Askarinejad et al, 2017; Ramezanianpour & Askarinejad, 2018). The students were required to use their device to access materials (online resources or library website, etc.) to work through the class activities (Askarinejad & Alton, 2018).

As shown in Table 1, the assignment included two parts, where the first part required the students to reflect on their own culture (their country of origin) in the engineering/construction context and the second part required them to research and learn about Māori cultural aspects and traditional construction and then look into examples where the design or construction has clearly integrated the cultural aspects.

Table 1: Sample assignment on embedding cultural concepts

Topic: Investigation on Engineering Design / Construction Applying Cultural Concepts	
Assignment objective: Prepare a presentation covering different aspects of engineering design / construction with focus on cultural perspectives. The presentation shall include two main parts:	
Part	**Brief**
A	An engineering design (a building or any other structure or infrastructure) in your country of origin (or a country of your choice) that clearly shows and incorporates cultural perspectives. - Research and find an engineering design example (case study) in your country of origin (or a country of your choice) that has clearly integrated the cultural aspects. - Explain the location, context, general design information, layout, materials, design features, etc. - Identify and demonstrate how the cultural aspects and cultural symbols are incorporated. - Show suitable and clear figures and photos in your presentation (with proper referencing).
B	An engineering design (a building or any other structure or infrastructure) in Christchurch or any other part of Aotearoa, New Zealand that clearly shows and incorporates the Māori cultural perspectives. - Research and find an engineering design example (case study) in Christchurch or any other part of Aotearoa, New Zealand that has clearly integrated the Māori cultural aspects. - Explain the location, context, general design information, layout, materials, design features, etc. - Identify and demonstrate how the Māori cultural aspects and cultural symbols are incorporated. - Show suitable and clear figures and photos in your presentation (with proper referencing).

Results and Discussions

The method used in this study is based on analysis of a case study through autoethnographic reflection by the authors where the lecturer's reflections and observations in class, plus the authors' reflections on students' assignment outputs are discussed.

Lecturer's reflections and observations in class

During the class discussion and activities on cultural concepts, a reasonably high level of engagement was observed. Students participated in various discussions and raised a number of questions. The conversations on cultural awareness and cultural humility provided an excellent opportunity for students to reflect on their own cultural backgrounds, their traditional worldviews, cultural symbols and traditions while also learning from their classmates of diverse cultural origins.

The initial discussions on general cultural aspects set the stage for conversations about Māori cultural values and traditions. With the groundwork of reflecting on their own cultures, students were better prepared to connect with the Māori indigenous culture. Various discussions in class during the Māori cultural discussions showed that the preliminary reflection the students had on their own culture, had facilitated a deeper appreciation and more meaningful engagement with the traditions and values of the Māori culture.

In some instances, the students were able to bridge their personal cultural experiences with other cultures (including those of the indigenous Māori), promoting a more comprehensive understanding

of the concepts of multiculturalism and bi-culturalism in the New Zealand context. For example, a Chinese student connected his own experience of ancestral worship or traditional festivals (like the Qingming Festival) with Māori concepts of mana and respect for ancestors, recognizing the importance of land and heritage in both cultures. As another example, one of the Indian students drew connections between the Māori practice of kaitiakitanga and the Indian tradition of ahimsa (non-violence towards living beings), leading them to appreciate the Māori focus on environmental stewardship.

Additionally, the discussions and associated class activities on the history of engineering and construction and the contributions from various cultures, emphasized how interconnected these contributions have been throughout history. These discussions highlighted that engineering and construction have never been the domain of a single culture but rather a collective human endeavour enriched by diverse cultural inputs. Students learned about various innovations and techniques developed by different civilizations each of whom brought unique advancements to the fields of engineering and construction.

Lecturer's reflections on sample students' project outputs

As a part of the assignment investigating the engineering design/construction applying cultural concepts (Table 1), the students produced group presentations where they discussed their findings related to parts A and B of the assignment. In part A, the presentations included a wide range of cases from various countries. The majority of the international students in the course came from East Asia, so they usually chose to look into cases from that region, for example, the traditional buildings or engineering/construction techniques from Vietnam, Philippine, Korea, China, Japan Taiwan, India and Nepal. The next few paragraphs, provide the authors' reflections on sample students' project outputs. These examples would be useful for educators teaching in engineering or construction areas who are interested in integrating practical relevant cultural examples in their teaching.

The Rong house was investigated by some of the students. Also called as tall house, these buildings are the symbol of Vietnam architecture in the Vietnam central highland. It is built mainly with natural materials such as grass, bamboo and other locally sourced wood materials. The Rong house of each ethnic group has its own specific characteristics in architecture, design, and decoration (Iizuka, 2012). In these structures, the construction of the tall roof is a complex process that involves creating a strong framework to support the thatch covering. This requires precise engineering to ensure the roof can withstand heavy rains and winds. The tall roof allows for efficient rainwater runoff and helps to regulate the interior temperature by facilitating air circulation.

The bahay kubo, or kubo, or payag (in the Visayan languages) or the traditional Philippine vernacular house represents the Philippine traditional architecture/construction. It is a type of stilt building indigenous to the Philippines (Cangas et al., 2013). The main structural elements, including the framework, flooring, and walls, are constructed using bamboo and wood, which are both lightweight and readily available.

Hanok (traditional Korean building) was investigated and presented by a couple of Korean students. The primary materials used in hanok construction are wood, stone, clay, and hanji (traditional Korean paper made from mulberry bark). The main structural system in Hanok consists of post and beam elements where the gravity load is generally resisted by post and beam and lateral load is resisted by walls. The wall used in Hanok is combined with wall-frame system (Kim, 2020). Traditionally, the connection between post and beam was made by mortise and tenon joint of only wood. For ventilation, the house contains a wooden flow hall called daecheong maru (Dacarro & Yim, 2021).

Dieh-Dou timber frame, commonly found in southern China, Taiwan, Singapore and Malaysia, is traditionally used in the construction of temples, ancestral halls and large residential buildings. Even though the Japanese traditional timber structures generally differ from the Taiwanese Dieh-Dou type, both traditional timber frames share key features such as the heavy roof loads, the

common stacking characteristics of the Dou-Gong complex brackets and the beam-column penetrating joint concept (Yeo et al., 2018).

The interlocking timber joints used in ancient Japanese and Chinese buildings has the potential to achieve increased sustainability by easing recycling, long-term maintenance, disassembly and reassembly. The mechanical behaviour of some of these joints and how this ancient technology can be used in today's building construction, is studied by Moradei et al. 2018. In the traditional methods, the structural items are joined together without nails. These types of wooden interlocking have improved gradually over time and have demonstrated reliable structural integrity (Moradei et al., 2018). The flexibility of timber and the joinery techniques allow Japanese wooden structures to absorb and dissipate seismic forces. These traditional joinery methods minimize the need for nails or adhesives, however, when needed, natural adhesives such as rice glue or resin may be used to increase the connection capacity.

Additionally, some students chose cases from Europe (such as Gothic cathedrals or Victorian buildings and churches), ancient Rome or Greece. A couple of students looked into examples from ancient Persia (such as windcatcher and sarooj). A windcatcher is a term used for wind tower, or wind scoop. It is a traditional building element used to create cross ventilation and passive cooling in buildings (Jomehzadeh et al., 2020). Sarooj is an early predecessor to concrete or mortar, where natural fibres were used in concrete-like materials; ancient Egyptians used straw mixed with clay and ancient Persians used Sarooj as mortar since 1200 BC. Sarooj was typically made of lime, clay, water, sand, ash and typha/cattail (Masoumi et al., 2015).

In Part B of the assignment, a range of different cases related to traditional Maori construction techniques and materials, plus the modern interpretation of Maori symbols and concepts in some recent engineering/construction projects were presented by the students.

Māori buildings were traditionally constructed using natural materials such as wood (typically native timbers like totara and kauri), flax, raupo reeds, and thatch. Similar to Japanese architecture, Māori buildings use a post-and-beam framework, providing structural stability and flexibility. The first known dwellings of the ancestors of Māori were based on houses in their Polynesian homelands. In New Zealand, these buildings were semi-permanent, had wooden frames covered in reeds or leaves, with mats on earth floors. Around the 15th century, larger buildings such as wharepuni – sleeping houses, pātaka (storehouses), kāuta (cooking houses) and whare whakairo (carved meeting houses) were built (Brown, 2014).

Skilled joinery techniques were employed, often without nails, to interlock wooden components. For instance, Mīmiro is a Māori construction technique, which uses interlocking compression joints, instead of bolting parts together. Mīmiro involves the use of interlocking structure supports with rope used to lash the supports together before tightening them to strengthen the building (Donaldson, 2023).

In addition to investigating the traditional Māori construction, the students researched and investigated modern engineering design examples in Christchurch or any other part of Aotearoa, New Zealand that had clearly integrated the Māori cultural aspects. Many students looked into buildings such as Tauranga (Christchurch central library), Christchurch bus interchange, Justice and Emergency Services Precinct and Te Hononga Christchurch Civic Building. These buildings integrate some elements of Ngāi Tahu cultural narratives, with design elements that reflect the tribe's heritage and the natural environment of the Canterbury region. For instance, featuring distinctive facades and interior design inspired by natural forms and traditional Māori patterns and the use of natural materials and colours reflecting the local landscape. However, it was discussed there are still a significant potential for further work on cultural integration in the engineering and construction projects in New Zealand.

The above discussions provide a valuable set of examples of cultural/traditional engineering/construction cases that can be used by engineering or construction educators. These examples can be potentially further explored and investigated through student assignments or activities in class or through capstone student projects. The engineering properties, the construction techniques or the engineering behaviour of these traditional structures or buildings

can be simulated, analysed, discussed and integrated in teaching relevant engineering or construction courses.

Additionally, the traditional methods and practices used around the world can offer an insight into current efforts for minimising the environmental impact through developing innovative sustainable designs and construction. For example, in New Zealand context, the studies on potential application of Mimiro technique in modern construction (Donaldson, 2023) or the recent studies on possible application of natural locally sourced materials and fibres (such as Harakeke) in engineering and construction (Askarinejad et al., 2023).

Overall, the assignment was well received by the students considering high engagement and high completion rate (pass rate). The assignment was attempted by 100% of the students in class which was a good sign of their interest and engagement, and they all completed the course successfully. The students worked in groups of two for this assignment. The international students seemed to enjoy the opportunity of sharing information about their home country. In many cases, the students seemed to have learnt more about the construction techniques in their own country of origin when working on the project. The local students also seemed to enjoy working on the project where they could appreciate and acknowledge their own cultural background while connecting that with the Māori values. The students' project works, their outputs and reflections underlined that understanding cultural contexts and historical perspective, are as important as technical expertise in making a positive impact on society. It should be noted that the method used in this study is based on analysis of a case study through autoethnographic reflection by the authors where the lecturer's reflections and observations in class, plus the authors reflections on students' assignment outputs were discussed. Certainly, other evaluation methods including students' surveys will provide additional valuable information in the next stages in future. Further research in this area is in progress.

Conclusions

In this paper, a case study of integrating the cultural aspects in an engineering/construction context was discussed. The concepts were incorporated in the teaching contents, class activities and within a course assignment/project. The students worked on a project reflecting on their own cultural background through investigation of historical and cultural engineering/construction practices and then exploring Māori cultural aspects in the context of engineering/construction.

It was observed that, reflecting on their own cultural identity along with exploring multicultural principles, prepared the students to engage better with other cultural concepts including traditional Māori cultural worldviews. The positive experience observed in this case study (including high students' engagement and completion rate) show that, particularly, in the New Zealand educational context, it is beneficial to recognize and value both biculturalism and multicultural principles, seeing them as complementary elements that enhance and strengthen each other.

Through this project, the students explored a variety of example traditional buildings or engineering/construction techniques from various countries and indigenous communities. This has formed a valuable set of examples of cultural/traditional engineering and construction cases that can be used by educators and can be potentially incorporated in teaching relevant engineering or construction courses.

Incorporating relevant case studies from diverse cultural contexts emphasized how the contributions from different cultures in terms of engineering and construction techniques have been interconnected throughout history. The realisation that engineers do things that people from their cultures do or have done or have contributed is very beneficial to engage and motivate the students. Additionally, it highlights the importance of valuing and learning from cultural/traditional methods and practices recognising their potential to inspire innovative sustainable practices in modern engineering and construction.

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