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A Theoretical Exploration on the Standing of Liberal Arts in the Civil Engineering Curriculum

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Abstract
Civil engineers' lack of humanities values might result in mismatches between the former and latter. One major hiccup and potential remedy to this situation lie in the civil engineering curriculum. This study aims to explore liberal arts in the civil engineering curriculum through a systematic literature review. This study is among the few recent undertakings that have relived the importance of liberal arts in the civil engineering curriculum to produce well-rounded civil engineers. Both technical and human skills are required to confront the dynamic and ever-changing society inherent in the growth of civil engineering students as future engineers.

Keywords: civil engineering; curriculum; liberal arts; systematic literature review

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1.0 Introduction

Civil engineering is a field that has existed since ancient times until now, the 21st century. As a field that has direct contact with society due to the deliverables for the people, transformation is inevitable as the world population is changing rapidly alongside the technological advancements and growing concerns on environmental issues. It is critical for a civil engineer to respond and adapt to such challenges. It would determine the resilience and success of the individual civil engineer and the profession itself. The dramatic change in technological and social aspects requires adjustments in how civil engineers are educated. Twenty-first-century civil engineers are expected to master communications, finance and economics, law and ethics, management, civil engineering heritage and future, human behaviour, social factors, and politics apart from the technical aspects such as design skills (Grigg et al., 2004). Thus, the recognition of the importance of liberal arts in the civil engineering curriculum.

The civil engineering curriculum has long been criticized and was demanded to be reformed by academics and industry professionals (Kim et al., 2016). The Royal Academy of Engineering (2007) has noted a concern that current graduates cannot apply technical knowledge to real-world problems. The critical issue highlighted by Swartz et al. (2019) is the misalignment between engineering practice and education, where the engineering practice emphasizes the integration between social and technical dimensions. Still, engineering education is inclined to the teaching of traditional technical concepts. The mismatch poses a challenge for engineering graduates. The

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challenges facing today's society are inherently socio-technical. They require collaborative, interdisciplinary solutions, which can be driven by professionals who have a solid grounding in engineering and the liberal arts (Bernhardt & Rossmann, 2019).

The American Society of Civil Engineers' (ASCE) Body of Knowledge (BOK2) also emphasized that the disciplines of humanities and social sciences are foundational pillars upon which to build an engineer's technical education (American Society of Civil Engineers, 2008). Therefore, there is a dire need to explore the current state of liberal arts in the civil engineering curriculum. Subsequently, recognizing the needs and challenges of integrating liberal arts into civil engineering curriculum in developing professional skills and attitudes that may assist in the future engineers' practice, such as autonomous and life-long learning, critical thinking, initiative, creativity, team working skills, responsibility toward society and their profession, entrepreneurialism and ethics (De Camargo Ribeiro & Mizukami, 2005).

1.1 Aim and objectives

This study aims to explore the current stand of liberal arts in the civil engineering curriculum. The following objectives have been established for this study: 1) To identify the number of articles related to liberal arts within the civil engineering curriculum papers, and 2) To highlight the needs and challenges of blending liberal arts in the civil engineering curriculum.

2.0 Literature Review

The demand for a globally relevant academic curriculum is higher than ever now, and globalization serves as an opportunity to reform civil engineering education. It also serves to broaden the role that civil engineers can play. Reform and innovation in engineering education are often motivated by the need to better prepare students for engineering practice in highly complex environments (Bell et al., 2019). The "aspirational vision" expressed at the 2006 ASCE Summit 2 invokes a vision of professional performance, which is mutually entrusted and accepted in 2025. The fulfilment of this vision requires professional activity supported by a flat base of liberal learning. Failure to provide students with an engineering education founded upon this flat base will compromise the established vision, recruit and prepare the best talent, express the value convincingly as a profession to the public, and perform holistically (Evans et al., 2007).

The interconnected social, environmental, economic, and even psychological components of global and sustainability concerns necessitate engineers skilled in transdisciplinary systems thinking to comprehend these challenges (McWhirter & Shealy, 2018). Civil Engineering is a technical discipline, and solid technical education must continue. Still, it also must be recognized that the contributions of civil engineers are significant to and for human society (Evans et al., 2007). However, the reality is that civil engineering students have little exposure to the liberal arts or critical professional skills (Stouffer & Russell, 2003). Moreover, little has been done to exploit the underlying value of non-engineering disciplinary toolsets in teaching the curricula (Masterton & Jeffrey, 2020). Thus, integrating liberal arts into civil engineering education is timely as the world faces fast-paced challenges such as climate change and industry 4.0.

Sanford Bernhardt and Rossmann (2019) highlighted that today's society is faced with socio-technical challenges that would require interdisciplinary solutions that could be driven by professionals who have basics in engineering and liberal arts. In general, the study of liberal arts could include political science and public administration, law, economics, history, sociology, behavioural science, finance, and economics. Russell and Stouffer (2005) mentioned that the purpose of liberal arts education is to develop the intellect in reasoning, judgment, and communication that challenges students to explore the world, further overcoming limitations to become better people, citizens, and engineers. In the US, Lafayette College has integrated engineering and liberal arts in the Bachelor of Arts (AB) in Engineering degree program, envisioned as a bridge between the two disciplines, educating "socio-technical engineers" since 1970 until today. Such action creates thoughts and triggers questions on the needs and challenges of why it is crucial to consider liberal arts in the civil engineering curriculum and why it has not been integrated widely to date.

3.0 Methodology

The methodology describes the research design of this study, which has been conducted using the systematic literature review (SLR) approach. The qualitative data from this study was further analyzed through thematic analysis using Atlas.ti 9.

3.1 Systematic literature review

The SLR in this study has been conducted using the Scopus database search engine. The Scopus database for SLR could be observed in construction management research works, such as in Taleb et al. (2021), due to its reputation as the largest peer-reviewed abstract and citation database for journals and proceedings. The initial search using the following keywords "curriculum" OR "curricular" and "civil engineering" has resulted in 2,147 returns. From the returns, the limitations (inclusion) have been set to only journal and English language articles, with total returns of 554. Furthermore, to align the findings to the intent of this study, the term "liberal art*" has been introduced, from which only 12 documents have returned, showing a tiny percentage (2.17%) of articles that have discussed liberal arts in the civil engineering curriculum. The 12 articles (full papers) were then thoroughly read, and the findings in addressing the objectives of this study are reported in the following sections.

3.2 The reporting

The twelve articles that have been included in this study are as shown in Table1. From the table, even though the trend of exploring liberal arts in the civil engineering curriculum is generally shallow, it is essential to highlight that the issue has been looming from 1984 until recent 2020. The trend shows interest in the subject matter between the time frame of the year 1984-1990. It was then dormant between 1992-

2000, and the subject matter was raised again from the year 2001 till recent, 2020 with most publications within this period. Hence, it demonstrates the relevance of liberal arts since earlier times and has since gained popularity in the civil engineering curriculum of the 21st century.

Table 1. Details of final articles

Title	Source	Authors and Year of Publication
Integrating the liberal arts into the body of knowledge for civil engineering systems engineers	Civil Engineering and Environmental Systems	Masterton and Jeffrey (2020)
Underpinning systems thinking in railway engineering education	Australasian Journal of Engineering Education	Kaewunruen (2017)
Proposal of a theoretical competence-based model in a civil engineering degree	Journal of Professional Issues in Engineering Education and Practice	Fernandez-Sanchez et al. (2015)
Case methods in civil engineering teaching	Canadian Journal of Civil Engineering	Newson and Delatte (2011)
Successful civil engineering education	Journal of Professional Issues in Engineering Education and Practice	Arciszewski and Harrison (2010)
General education for civil engineers: Sustainable development	Journal of Professional Issues in Engineering Education and Practice	Kelly (2008)
Survey of the national civil engineering curriculum	Journal of Professional Issues in Engineering Education and Practice	Russell and Stouffer (2005)
A viewpoint on software engineering and information systems: What we can learn from the construction industry?	Information and Software Technology	Avison and Wilson (2001)
An ethics and professionalism seminar in the civil engineering curriculum	Journal of Professional Issues in Engineering Education and Practice	Koehn (1991)
Need for "Professional" education for professional engineers	Journal of Professional Issues in Engineering Education and Practice	Fenske and Fenske (1990)
Construction education and research in central Europe	Journal of Construction Engineering and Management	Halpin et al. (1987)
The civil engineering degree: Education or training?	Journal of Professional Issues in Engineering Education and Practice	Vild (1984)

Based on the final articles, countries related to publishing articles of integrating liberal arts in a civil engineering curriculum are shown in Figure 1.

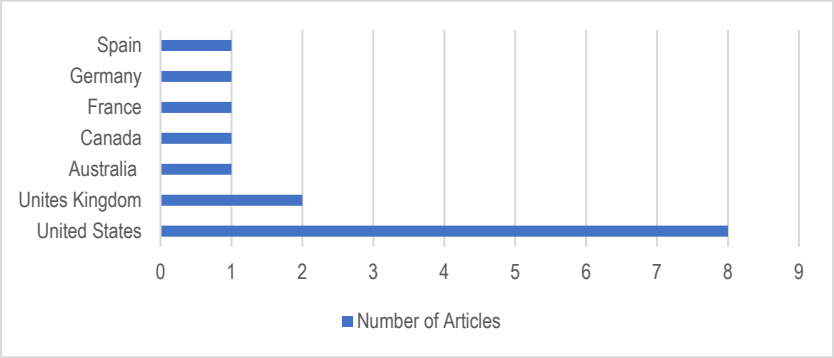

Fig. 1: Final articles and the related countries

4.0 Findings

The findings section is divided into two sections that address this study's two main objectives: to explore the needs and challenges of integrating liberal arts into the civil engineering curriculum.

4.1 *Needs of integrating liberal arts into the civil engineering curriculum*

From the SLR, integrating liberal arts into the civil engineering curriculum could generally be categorized into three main themes, as shown in Table 2. The determination of the themes has been done based on the nature of the needs (thematic analysis). Variables related to the needs regarding academics have been placed under curriculum; needs for instilling certain beliefs or guide for actions were placed under the values component, while needs by the industry under industry requirements component. All variables have been retrieved from the twelve final articles; thus, all citations could be referred to in Table 1.

Table 2. Theme and variables for the needs to incorporate liberal arts in the civil engineering curriculum

Curriculum	Values	Industry Requirements
1. A balance between the qualitative and quantitative aspects	1. Creativity	1. Professional practices
2. Move towards sustainability	2. Professionalism	2. Demands from the industry
3. Embedding soft skills	3. Communication	3. Management abilities

4. Student-centred teaching and learning approaches	4. Sustainability	4. Interaction between engineering with political, ethical, and social decision making for tomorrow's engineers
5. Interaction with the bigger world	5. Intellect in reasoning and judgement	5. Reduced demand for civil engineers due to narrow-minded
6. Broad, holistic education for broad-based knowledge	6. General knowledge	6. Fulfil society's needs
7. Professional development	7. Life-long learning	7. Well-rounded engineers
8. Threat and competition to the civil engineering programme	8. Humanities	8. Current trend
	9. Harmoniously developed personality	9. A new breed of civil engineer
	10. Employability skills	10. Socio-technical system

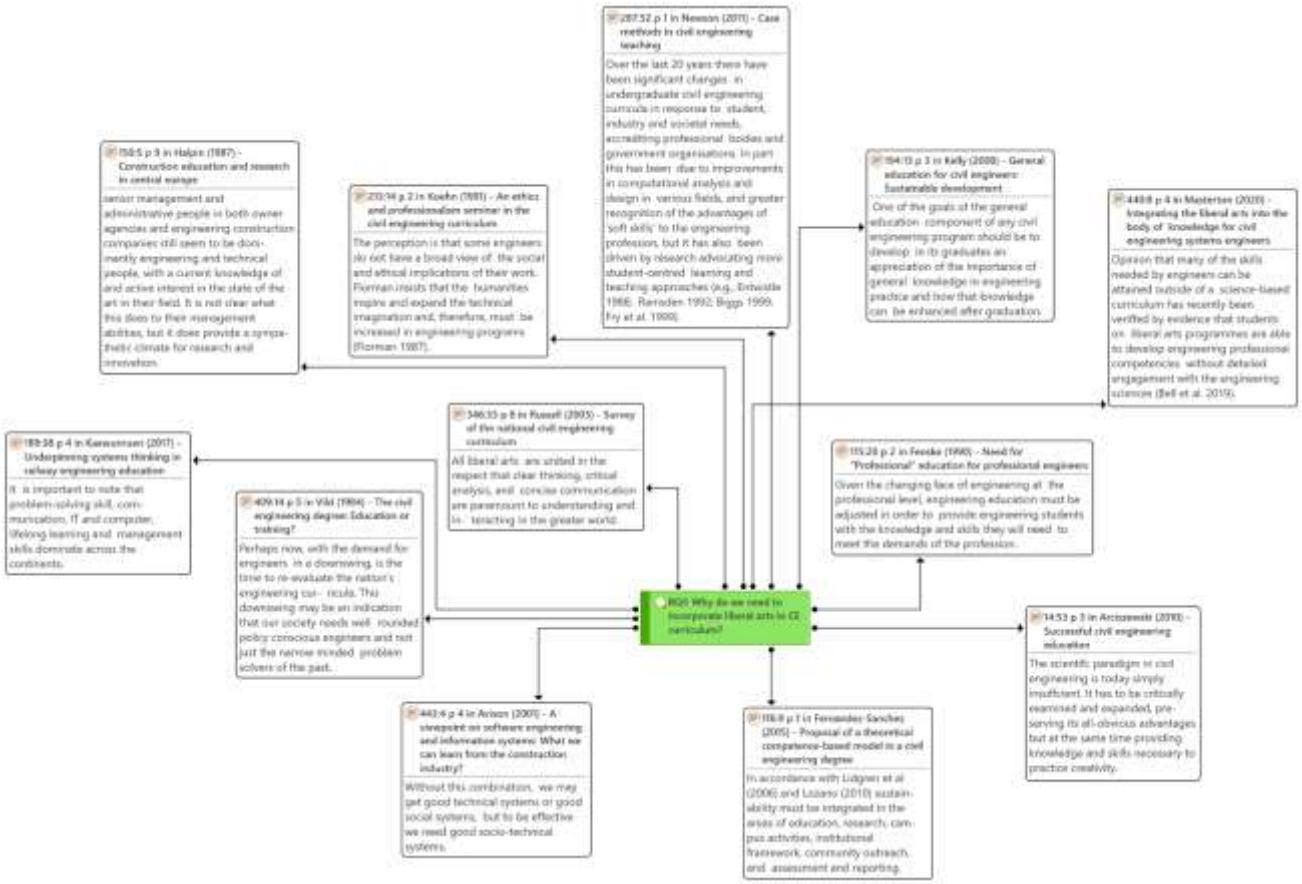

Fig. 2: Network view of literature evidence on the need to incorporate liberal arts in the civil engineering curriculum

The main themes of curriculum, values and industry requirements are interlinked. The increased emphasis on curriculum will lead to more positive values, which will address industry needs. From the curriculum aspect, concerns were raised regarding the need to balance the quantitative and qualitative aspects of the curriculum. A soft skill, student-centred teaching style, and the provision of broad, holistic education that prepares students as professionals points towards sustainability need to be emphasized. Upon addressing the needs, potentially the current threat and competition with civil engineering programs could also be relieved.

Regarding the value component, several elements that are absent and need to incorporate liberal arts are enhanced creativity with intellect reasoning and judgment. Also necessary is the need to possess professionalism and employability skills with good communication, alongside a harmoniously developed personality with general knowledge. Such values would further instil the values of humanities, life-long learning, and sustainability. From the aspect of industry requirements, the factors that have driven the need to incorporate liberal arts are the quest by the industry that demands a new breed of civil engineers who are well-rounded with professional practices and management abilities, able to fulfil current society's needs by assimilating engineering with politics, ethics and social dimensions that addresses the socio-technical system. Figure 2 shows network views of literature evidence on the subject matter.

4.2 *Challenges of integrating liberal arts into the civil engineering curriculum*

The challenges of integrating liberal arts into the civil engineering curriculum can be categorized into three main components: curriculum, value/attitude, and governance, shown in Table 3.

Table 3: Theme and variables for the challenges to incorporate liberal arts in the civil engineering curriculum

Curriculum	Values/ Attitude	Governance
1. Heavy reliance on Bloom's taxonomy	1. Lack of motivation for change	1. No proper framework or guideline on how to integrate liberal arts

2. Stagnant, slow in making changes	2. Change resistance	2. Isolation between engineering education and primary university curricula
3. Focus on technical courses and neglect non-technical courses	3. Rigid mindset	3. The constraint of 4 years curriculum structure
4. Unable to blend liberal arts into civil engineering curriculum (incompatible/ incoherent)	4. Conservative and unimaginative thinking	4. Packed curriculum with engineering technical content
5. The current curriculum is more focused on critical and analytical ability	5. Resistance by students for having to read a lot	5. Professional engineering bodies impose the most significant challenge to progressive change
6. Reliance on deductive instructional methodologies	6. Silo thinking	6. Training budgets and time
7. Challenge in creating a holistic civil engineering program	7. Undermining the value of non-engineering discipline	7. Various academic associations with different schools of thought

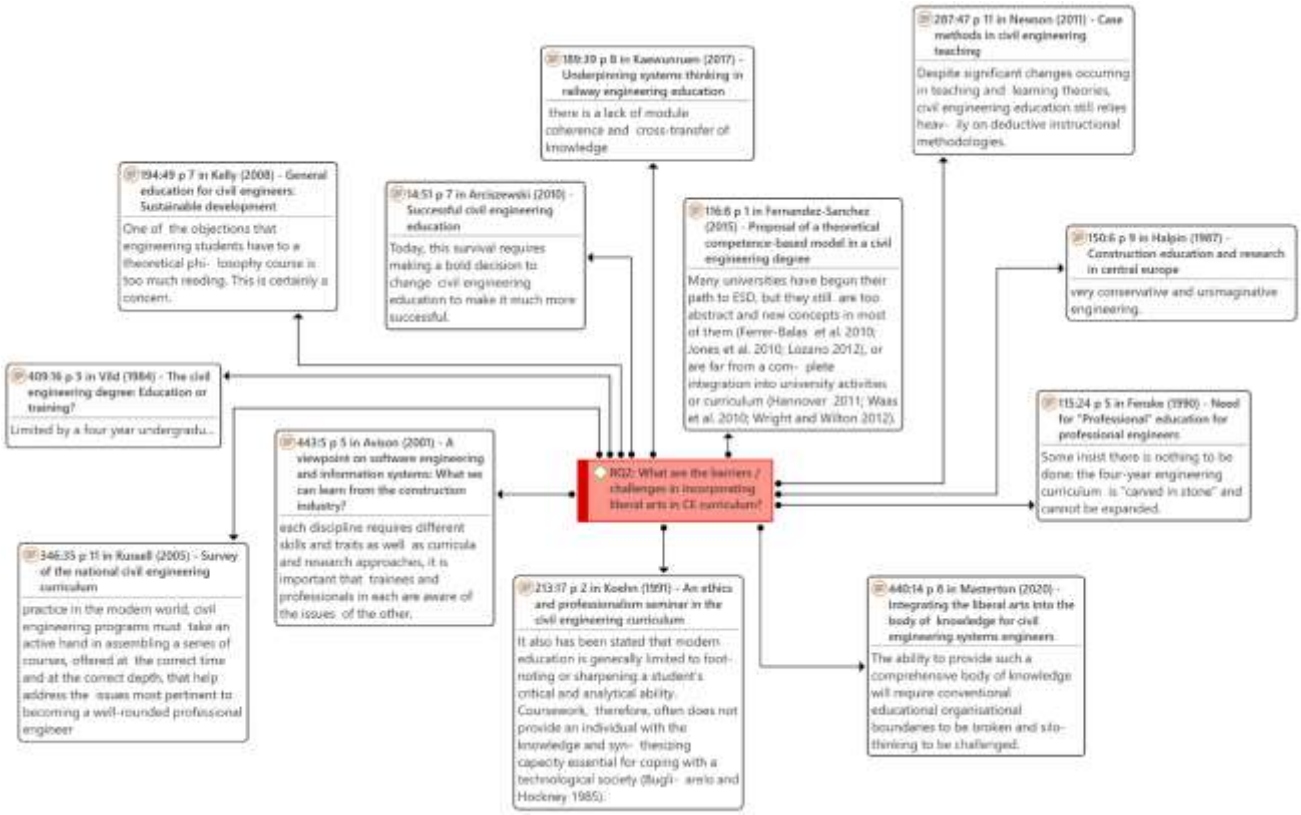

Fig. 3: Network view of literature evidence on the challenges to incorporate liberal arts in the civil engineering curriculum

From the curriculum perspective, the current heavy reliance on Bloom's taxonomy, which targets technical courses compared to non-technical courses, poses a challenge in creating a holistic civil engineering program. The curriculum that predominantly focuses on the critical and analytical ability that relies heavily on deductive instructional methodologies creates difficulties for academics to blend liberal arts with the civil engineering curriculum. Apart from that, the civil engineering curriculum has also been criticized by scholars for the stagnant, non-dynamic curriculum that is slow in making changes. Change is critical regarding value/attitude as academics lack motivation and resist changes due to conservative and unimaginative thinking. The thoughts and perception could also be influenced by the silo and rigid thinking that undermines the value of the non-engineering discipline. Similar resistance also develops among engineering students who associate liberal arts with the need for lots of readings. From the governance perspective, scholars claimed rigidity as an issue where the constriction four-year curriculum structure is packed with technical content that isolates engineering education from primary university curricula. In addition, threats are also apparent from engineering professional bodies and academic associations due to different schools of thought and the lack of mutually agreed-upon framework or guidelines for integrating liberal arts into the civil engineering curriculum. In general, the three main components are interrelated. The change in governance could influence the value/ attitude of the academics in developing a holistic curriculum that incorporates liberal arts. Figure 3 shows network views of literature evidence on the subject matter.

5.0 Discussion

The needs outweighed the challenges of incorporating liberal arts into the civil engineering curriculum. Both elements of needs and challenges should be considered to integrate liberal arts in the civil engineering curriculum. The relevance of introducing liberal arts stretches from students' achievements to the profession itself, which can eventually give back to society. Civil engineers' context and perception could be changed, making way for the new breed of civil engineers. Challenges or barriers could also be reversed with the

provision of drivers as the strategies that could be established to address issues at the governing level. It could descend to the value and, ultimately, the curriculum.

6.0 Conclusion & Recommendations

This study has explored the standing of liberal arts in the civil engineering curriculum, where very minimal studies (2.17%) have been conducted on this subject matter. However, judging from the continuous existence since decades ago, along with the current inclined interest by scholars, demonstrates the importance of this subject matter in ensuring a holistic curriculum. The findings on the needs and challenges of integrating liberal arts into civil engineering curriculum could be categorized into the curriculum, value/attitude, and industry requirement/governance. In addition, this study has shed some light on the previously ignored reforms in the civil engineering curriculum, particularly on liberal art that would benefit the different levels of stakeholders. Future research should be done to reconfirm the qualitative findings through quantitative approaches, potentially expanding it to include case studies.

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Paper Contribution to Related Field of Study

This paper contributes to the field of civil engineering curriculum by first exploring the current stand of liberal arts and highlighting the needs and challenges of incorporating liberal arts into the civil engineering curriculum, which was previously scarce. This notion is expected to change the common mindset and practices in the current civil engineering curriculum to produce new breeds of 21st-century civil engineers.

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