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Making A Case for an Interdisciplinary Approach to Water Education Towards Sustainable Development

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Abstract

Traditional engineering education has focused on design principles and the integrity of products. It includes the designs for water supply and sanitation systems, water resources management, hydraulic structures, to name a few. However, this approach has led to a gap in design and implementation, leading to challenges in product uptake and sustainability. Water is central to several Sustainable Development Goals (SDGs), creating a web between the technical, environmental, social, financial, policy, and governance subsectors. Water engineers are critical to attaining the SDG goals; therefore, they must be trained to acquire the skills required for the task. For example, the WASH humanitarian sector has reiterated that the lack of the right expertise has been a bane to the delivery of interventions. Sustainable water projects must incorporate techno-centric, eco-centric, and Socio-centric concerns. A redirection of the water syllabus to include all the necessary aspects is the step towards transferring and acquiring the required skills. Content review is critical when water education sits within a civil engineering program. This paper presents calls for interdisciplinary engineering education from literature. It highlights the benefits of interdisciplinary water engineering education. The paper also provides approaches taken by the author to design and deliver interdisciplinary water modules and feedback from the students on each of the approaches. Overall, advocates for educators, universities, and training institutes to produce graduates who understand water engineers' dependence on other sectors for successful and more-sustainable solutions for society.

Keywords: Capacity development; Engineering education; Interdisciplinary; Sustainable development; Water education

1. INTRODUCTION

Engineering applies scientific knowledge, technical methods, design principles, and management concepts to everyday challenges (UNESCO, 2021). Engineering education entails applying technical, scientific, and mathematical knowledge to natural laws and physical resources(Iqbal Khan, Mourad, & Zahid, 2016). It entails technological and organisational skills that meet human beings' daily needs and lead to a higher quality of life. Traditional engineering education has focused on the fundamentals of engineering and design principles and techniques and the integrity of products. The traditional focus would include designing for water supply and sanitation systems, water resources management, and hydraulic structures in the water sector. However, this approach has led to a gap between design and implementation, leading to product uptake and sustainability challenges. Traditional methods of academic instruction, such as lectures, may inadequately prepare students to transition from the classroom to the profession (Steinemann, 2003). Since engineering programs are mainly designed to provide the basic undergraduate education in a specific engineering discipline and/or continue formal engineering education (Iqbal Khan et al., 2016), students typically graduate with theoretical knowledge but little experience in real-world problem-solving. Engineering projects aimed at sustainable development fail due to the lack of critical thinking about adverse impacts (Haque & Sharif, 2021) on people and the environment. Technology cannot be designed and deployed as though it has no environmental or societal implications.

Interdisciplinary refers to the integration of knowledge or thinking practices. With interdisciplinary teaching, students are exposed to new and existing knowledge from various disciplines (Lattuca, Voigt, & Fath, 2004; Navarro, Foutz, Thompson, & Singer, 2016). Key factors hindering engineering development include a lack of engineering capacity, international interdisciplinarity, and cross-sectoral collaboration. Training engineers to implement the Sustainable Development Goals (SDGs) necessitates more than just new skills in creative learning, thinking, and complex problem-solving. It should incorporate interdisciplinary, international cooperation, and an ethical attitude. Through interdisciplinary approaches, students learn to appreciate other disciplinary knowledge as essential to the practice of their disciplines.

2. SUSTAINABLE DEVELOPMENT and INTERDISCIPLINARY NATURE OF WATER

Dodds and Venables (2005) define sustainable development as "an approach to environmental and development issues that seeks to reconcile human needs with the capacity of the planet to cope with the consequences of human activities." Sustainable development is at the heart of science, technology, and engineering. The trio contributes to developing innovative strategies for sustainability transformations (UNESCO, 2010, 2021). It, therefore, highlights the need to recognise the importance of science, technology, and engineering in achieving the SDGs (Duarte et al., 2020). The future of engineering is incorporating sustainability into professional practice (Haque & Sharif, 2021) by being increasingly aware of technology's environmental and social impacts (Duarte et al., 2020; UNESCO, 2021). Engineering education must incorporate the different dimensions of sustainability, as shown in Figure 1. All the dimensions connect to water resources, management, and engineering. Therefore, it is expedient that water education considers all these aspects even when the education sits within an engineering curriculum.

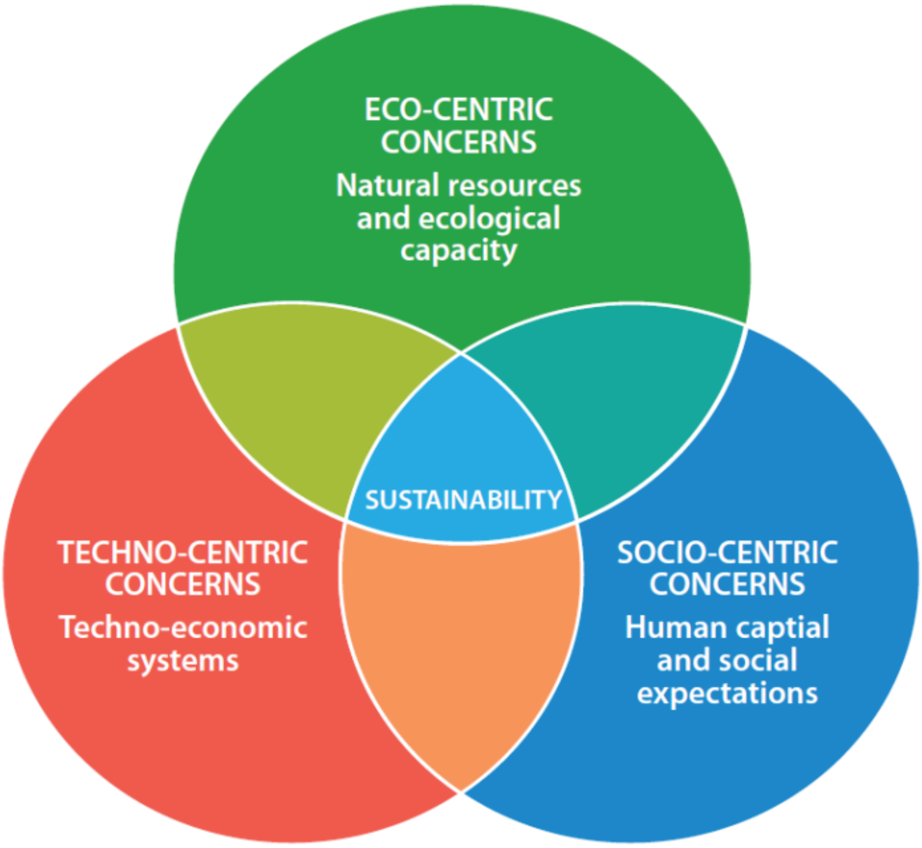

Figure 1. Dimensions of Sustainability Source: (Dodds & Venables, 2005)

The UN SDG 6 with the theme "Ensure availability and sustainable management of water and sanitation for all" has 8 targets and 11 indicators covering different areas that lead to improved quality of life. Consequently, water maps to all other SDGs are shown in Figure 2. For example, prioritising the water needs of the poor would prevent pollution of water (SDG 14), improve agriculture and availability of food (SDG2), result in better health conditions (SDG 3), ensure girls go to school (SDG 4), thereby reducing inequality (SDG 10). It shows that water-related solutions are multifaceted and should be approached as such. A common occurrence in the water sector is the lack of capacity to adequately design and implement interventions such that the interventions remain sustained in perpetuity. International actors in the WASH sector have recorded several failed water projects. One of the reasons is the inadequacy of professionals trained to handle the complexities of water-related interventions (Jimoh & Jacob-Oricha, 2022). Sustainable interventions in the humanitarian or development sector require water professionals to understand, appreciate, and approach projects with an interdisciplinary lens, which can be prepared for by an appropriate and all-encompassing water curriculum.

Figure 2. Water and Sanitation in the Sustainable Development Goals (Sanitation and Water For All, 2017)

Integrated Water Resources Management (IWRM) introduces the concept of Cross-sectoral integration. Global Water Partnership (2000) defines IWRM as "a process which promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare equitably without compromising the sustainability of vital ecosystems." Toolboxes have been produced as guides to practitioners to achieve water security. For effectiveness, professionals should not be left to learn the concept of IWRM at the point of use. Instead, it would be of tremendous advantage if it was introduced earlier in water engineering education at undergraduate and postgraduate levels. Assessments can also be designed to evaluate student reports based on the economic, environmental, and social pillars of sustainability considered (Duarte et al., 2020).

3. TRANSITIONING TO INTERDISCIPLINARY WATER ENGINEERING EDUCATION

There are several ways to transition the traditional water engineering curriculum into an interdisciplinary one. Some of these approaches can be implemented by lecturers leading water modules or courses, while some transitioning could be done at departmental or faculty level to the entire curriculum of a water program. Many higher institutions across the world have created entire water programs that are interdisciplinary, some of which have been championed by national water research institutes or universities in response to the complexities of global challenges. An example of an international institution with interdisciplinary water education is the IHE Delft Institute for Water Education. The most effective change would be at individual levels of existing water modules or courses as it reaches a more significant number of participants. Approaches to transitioning water modules to interdisciplinary ones are summarised in Figure 3. The author discusses in this section some of the approaches they have used in their delivery of water modules that individual lecturers can champion. Students' feedback on the approach is also presented for each of them.

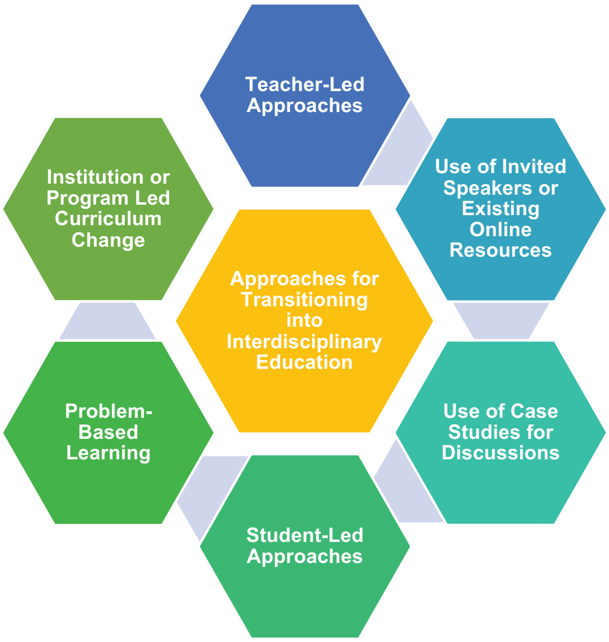

Figure 3. Approaches for Transitioning into Interdisciplinary Education

3.1 Teacher-Led Approaches

Change can be implemented by the lecturer when there is an existing curriculum. The module's contents can be delivered considering and including principles that govern engineering for sustainable development shown in Figure 4. For example in designing a dam, a typical curriculum would focus on technical knowledge such as water demand, hydrographs, the hydraulic structure, structural integrity, construction works. An interdisciplinary approach can include the social effects of having large dams, dams on transboundary rivers, the human rights associated with dams, the effect of dams on the ecology, environmental impact analysis, cost-benefit analysis and water policies. The new additions do not have to be necessarily covered broadly; however, introducing them creates a holistic awareness of all-things dam. Students can then learn more about them through self-study or at postgraduate levels. Comments from students on a water module that have incorporated the approach includes:

"The lecturer ensured that different facets of water were touched. She explained and made sure we understood different contexts."
"The content, in general, was very engaging and gave a good overview of various water-related issues across the world."
"I appreciated learning more about the complexities when it comes to water supply and sanitation. Water is indeed a human right."
"The module covered water and sanitation technology in a way which was not exclusive at all to any one discipline but rather focused on the topic (water and sanitation technologies). As such the module would be relevant to any modules for which water and sanitation technologies are pertinent."

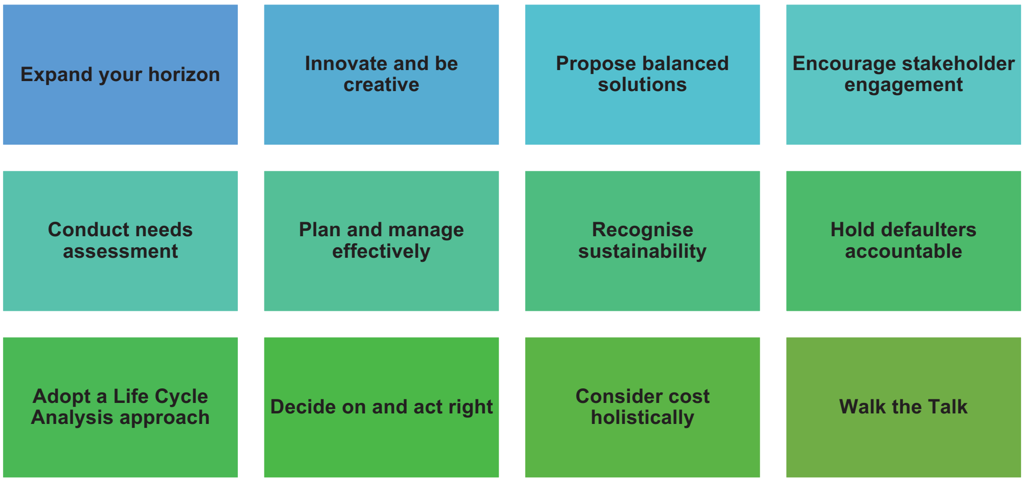

Figure 4. Principles that Govern Engineering for Sustainable Development. Adapted from (Dodds & Venables, 2005)

3.2 Use of Invited Speakers or Existing Online Content

The lecturer might not be vast in a particular aspect of water that is non-technical. A way around this is to invite guest speakers that work on water themes to speak about their research or work. They can be from ecology, agricultural science, sociology, economics, law and development studies. Having other people's input enriches the discussion, and the students begin to appreciate that to have sustainable solutions and projects, they need to work with people from other disciplines. Existing educational videos online or Ted talks can also be used as educational resources that provide interdisciplinary content for curriculum delivery. Feedback has shown that students appreciate the variety of technology-led teaching that these resources bring and their content. Students were asked what they liked about the module. Some comments that relate to guest lecturers and online content include:

"Extra video clips which showed the real-world application or its significance. The lecturer put effort to make the presentations visually attractive and found other resources to aid in learning".
"Range of technical knowledge on WASH. Very useful to hear real-life implementations of both WASH and hydroponics by guest speakers."
"The addition of guest lectures also helped provide different perspectives."

3.3 Use of case Studies for Discussions

Haque and Sharif (2021) emphasised that environmental engineering education can succeed by including community mapping in its curriculum. One way to incorporate community mapping is using case studies to elicit class discussions on the various aspects of a water-related topic. Figure 5 shows an example from the author's use of case studies in the class. Some comments from learners include:

"I really enjoyed the in-class discussions! The examples and case studies in the presentation were also useful."
"We had some informal discussions at one point about different ideas of solutions and I would really like those to return, those pushed me to think more solidly on the content and engage in a non-pressured way, unlike when answering numerical questions."

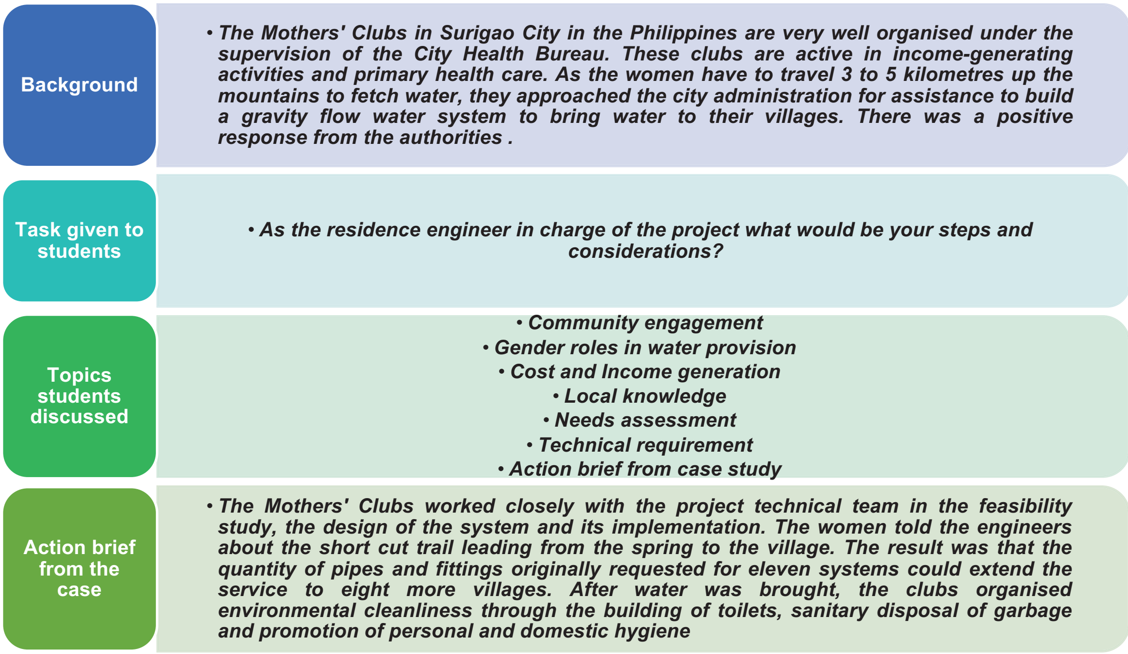

Figure 5: Use of Case Study in Water Engineering Education. (Note: Background and Action brief from case sourced from (Reed, 2002))

3.4 Student-led Approach

Interdisciplinary water education can also be introduced through student-led learning. In this instance, the students are directed to research non-engineering aspects of water education; avenues can be created to present their research to ensure that the whole group benefits from this learning. The presentation times can be embedded in the class sections or planned as additional sessions. To ensure active listening and increase engagement, the other students are graded on their level of participation. This activity ensures that students learn non-engineering and interdisciplinary aspects of water through self-paced learning student-taught sessions while honing their communication skills. Examples of such topics are

- Water and Faith-Based Values.
- The Monetization of Water
- The Values of Water for Peace, Security and Transboundary Cooperation.
- The Values of Water for Mental Health and Life Satisfaction.

Student feedback on the approach include:
"This gives the flexibility to students to determine their own focus to present on from the given scope, and there could presumably be completed by any discipline."
"Extending the module to a wider range of students would benefit the students that take the module as they would be able to learn a wider perspective from the presentations."

3.5 Problem-based Learning

Problem-based learning emphasises learning by doing, allowing students to develop problem-solving skills (Steinemann, 2003). In problem-based learning, students are given a real-world problem similar to those they face as professionals. The lecturer acts as a coach while the students take ownership of the problem and the problem-solving process. Research shows that real-world projects focusing on sustainability positively impact students' critical thinking skills and knowledge of sustainability (Duarte et al., 2020). Mihelcic, Phillips, and WatkinsJr. (2006) postulated that incorporating project-based learning into environmental and civil engineering curricula can primely position the disciplines and their graduates.

An organisation that has promoted problem-based learning for engineering students is the Engineers without Borders, UK. The UK branch has continuously supported problem-based learning through the yearly delivery of their Engineering for People's Design Challenge. For each challenge, vital thematic areas that inadvertently include water, sanitation, waste, food, and land management have provided an avenue for learners to see water-related to other aspects of society. Students are encouraged to highlight the choice design's social, economic, and environmental influences. Students working with others from other disciplines also means that they can learn from the insights of others from other disciplines such as electrical, mechanical, agricultural, and systems engineering.

Feedback from students on problem-based learning within their water modules include:
"I enjoyed the activities and the group learning."
"I love the diversity of backgrounds and viewpoints we have within the class!"
"I thought that the range of views and experience was perfect. The whole cohort worked well. The group discussions and exercises were really good too."

4 CONCLUSIONS

Engineers must better understand their roles and responsibilities in achieving the SDGs. In particular, water engineering graduates must appreciate the uniqueness of their discipline and its connectivity to all facets of sustainability and quality of life. Training water engineers to implement the SDGs must transition from traditional approaches to completely embody ethical, interdisciplinary, and international perspectives in addition to creative learning, critical analysis and complex problem-solving. The advocated change can be at the institutional or program level as well as at the single module levels championed by individual educators. The proposed approaches to transitioning into Interdisciplinary education at individual levels can be classified as; Teacher-Led Approaches, Use of Invited Speakers or Existing Online Resources, Use of Case Studies for Discussions, Student-Led Approaches and Problem-Based Learning. These approaches can be used singularly or combined as appropriate for each module or lecturer. Apart from water engineering, these approaches are also relevant to other disciplines. Feedback from students shows that they are excited about the styles and the interdisciplinary content they are exposed to, which gave them a holistic view of water themes. The discussion from the paper shows that minor tweaks to delivery can have a considerable impact. Ultimately, the interdisciplinary approach to water education builds capacity for sustainable development and equips graduates for leadership positions in the global economy.

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