Demystifying Humanitarian Engineering: A comparative study on perceptions in UK and Asia

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***Abstract*— Humanitarian Engineering is defined as the integration of engineering with sciences, social sciences and arts to invent, create, design, develop, or improve technologies, processes and tools which promote the well-being of communities facing grand humanitarian challenges. Introducing aspects of humanitarian engineering to engineering graduate curricula offers the advantages of seeing science, technology and engineering in a broader perspective, offering students the opportunity to experience engineering on a global and international context, enabling transferrable skills and enhancing graduate employment prospects. Nevertheless, evidence on how a number of stakeholders perceive the concept of humanitarian engineering is missing. This article presents and discusses the findings of a comparative qualitative study undertaken among engineering academics, industry professionals and practitioners in the UK and three Asian countries; Vietnam, Indonesia and Bangladesh. The participants provided information on what humanitarian engineering means to them, how important it is for the communities they live in, and what humanitarian professional attributes are needed to professional engineers. Findings from this study indicate that humanitarian engineering is perceived as the use of engineering to alleviate poverty, ensure sustainability to communities and tackle global challenges. The study indicates that by receiving experiences in humanitarian engineering, a number of key professional attributes would be enabled, involving the ability to manage resources more effectively, solve complex problems which require interdisciplinary inter-professional competencies and demonstrate leadership and social influence; all of those being highly appreciated by employers.**

Keywords—humanitarian engineering, innovative curricula, engineering education, active learning strategies

I. Introduction

Asia is the most populous continent, home to the fastest growing economies and the world's most disaster-prone region [1]. Because 85% of global fatalities related to natural disasters occur in Asia, the region's priority is to invest in building safe infrastructure [2]. SE Asia, in particular, is investing $323 billion in new infrastructure in 2018 (and more in the next years).

Concerns against having safety-critical infrastructure are related to lack of professional engineers with appropriate higher education and skills, and capacity to apply safe engineering during practice. For example, over the next decade, the engineering industry in SE Asia is expected to experience the worst shortages of professional engineers, e.g. in Indonesia the shortfall of engineering graduates is projected to increase to more than 70% in 2025 from a 40% shortage in 2013 [3]. In addition, metrics are showcasing the poor capacity in practice, such as 700 occupational fatalities in Asia every day, with at least one-third of these occurring in SE Asia, and most of them related to the engineering profession. If the rate of fatal occupational accidents in SE Asia is reduced to European levels, more than 100,000 lives per year would be saved.

Poor standards and regulations, and limited professional skills leading to poor application of safe engineering, later failures in structural integrity and new casualties, are related to ineffective higher engineering education [3][4].

In response to the aforementioned, and according to what Boston Consulting Group [5] recommends, to help close the skills gap, action must be taken in shaping engineering curricula to promote creative interdisciplinary community-based education i.e. by introducing educational concepts such as the one of humanitarian engineering, and endorse innovative pedagogies offered to ensure that tools utilized by educational providers are of the highest quality.

Humanitarian Engineering is defined as the integration of engineering with science, social science, arts and humanities to invent, create, design, develop, or improve technologies, tools and processes which promote the well-being of communities which are facing grand humanitarian challenges, ensuring safety and sustainability. Humanitarian engineering brings enhanced well-being, welfare, and comfort to individuals or communities in disadvantaged circumstances. To this respect, humanitarian engineering aims at offering a co-evolutionary, innovative, conceptual framework in graduate engineering education for disadvantaged and unsupported communities.

This article aims at presenting a comparative study of perceptions in UK and Asia on the concept of humanitarian engineering in graduate engineering education and provides insights for the higher education, research and professional communities. Moreover, the article informs wider debate in society about the engineering-related humanitarian challenges.

The study presented in this article was conducted within the framework of the project ENHANCE- ENabling Humanitarian Attributes for Nurturing Community-based Engineering (project No: 598502-EPP-1-2018-1-UK-EPPKA2-CBHE-JP (2018-2582 / 001-001), funded by the Erasmus + KA2 Cooperation for innovation and the exchange of good practices – Capacity building in the field of Higher Education. This is a 3-year collaborative multi-partner project, listing 9 partner Higher Education Institutions from UK, Greece, Vietnam, Indonesia and Bangladesh. The project is coordinated by the University of Warwick (UK).

II. Background and Rationale

The International Federation of Red Cross Societies Strategy 2020 [4][6] states that Asia-Pacific continues to be the world's most disaster-prone region, where countries suffer from insufficient implementation capacity and the strategic aims in the region are to: (a) save lives, protect livelihoods, and strengthen recovery from disasters and crises; (b) enable healthy and safe living; (c) promote social inclusion and a culture of non-violence and peace.

In more detail, major challenges in the region are identified as follows:

- the Asia-Pacific region has been significantly affected by natural disasters. In the decade 2000-2009, 85 percent of global fatalities related to natural disasters occurred in the Asia-Pacific [2], making it one of the most vulnerable regions to natural disasters and other environmental changes;
- the importance of education in supporting community-based practices on prevention, preparedness and mitigation in response to the deleterious impacts of climate change and environmental degradation is critical in SE Asia [3]; According to the World Economic Forum on ASEAN, in several SE Asian countries, a large number of students are studying social sciences, business and law, while enrolment in subjects that will be critical to taking advantage of technological change, sustainability and safety, such as engineering, health and the natural sciences, lags behind;
- curriculum reforms promoting non-cognitive and higher-order skills, as much as academic content, are needed. Overloaded curriculum and a heavy focus on academic knowledge are features of many SE Asian countries. Curriculum reforms, in high income and high-performing countries, have already taken place, promoting the acquisition of non-cognitive and higher-order skills or transversal competencies such as innovation, creativity and communication. While this trend is expected to continue, countries in the SE Asia face challenges in integrating what may be termed 'transversal competencies' or 'non-cognitive skills' in curriculum pedagogy and assessment [3];
- lack of skills and ignorance of skills' gaps. British Council [4] makes reference to the lack of technical and soft skills with problem solving and analytical skills, leadership and decision making, teamwork and interpersonal skills being amongst the skills needed by businesses and society, currently unavailable to the workforce. The Boston Consulting Group report of May 2013 [7] suggests that the engineering field is expected to experience the worst shortages of skilled people in the next decade in the region, for example in Indonesia, the shortfall of engineering graduates is projected to increase to more than 70 percent in 2025 from a 40 percent shortage in 2013. The report suggests that shortages at senior levels will refer to lack of the global

exposure and leadership skills needed to succeed. Limited or no information is available on skills gaps for other countries in SE Asia due to lack of relevant skills' gaps surveys [3].

According to the Asian Development Bank reports [2], [8], major constraints in higher education are the traditional methods of instruction, examination, and student evaluation. The traditional models of artificial separation of knowledge, disciplines and skills seems to be no longer relevant. Universities provide education using mainly traditional methods, such as lectures and the evaluation of students through written examinations, with hardly any modern methods like: case analyses; presentations; group work; simulations; business games; term paper writing; formative assessment (including quizzes). There is need for introducing the integrated nature of knowledge and understanding, as it is applied in an everyday context to be central to creativity and innovation—one cannot think in silos and be productive in a knowledge economy.

Introducing aspects of humanitarian engineering to graduate engineering curricula offers pedagogical advantages such as seeing science, technology and engineering in a broader perspective, offering student experience on a global and international context, enabling transferrable skills and enhancing graduate employment prospects. Nevertheless, evidence on how stakeholders perceive the concept of humanitarian engineering and whether they believe that the current engineering curricula and pedagogies enable professional attributes for tackling humanitarian challenges was missing.

III. Methodology

The methodology for carrying out the study involved qualitative research through four practice dialogue workshops, run in UK and Asia (Vietnam, Indonesia and Bangladesh) involving a variety of national, international and local stakeholders (industries; NGOs; governmental organisations). In total 120 participants have been consulted; 30 participants from each country allocated into groups of 5 members each with 60% of each group being male and 40% female participants.

The sampling was purposive. The participants were invited by the project researchers, to ensure the diverse and interdisciplinary, inter-professional sample that is needed to answer the research questions. The sample was such to ensure that the intended benefits of ENHANCE reach the local stakeholders (industries; NGOs; governmental organisations etc.) who should be able: (a) to influence and shape the engineering curriculum and the models of engineering education in order to produce the talent needed; (b) to develop effective graduate engineering programmes; (c) to contribute real problems and projects for students to solve and realise solutions to the community's real-life problems. Table I sets out the type of participants and number of participants per type for each group. All participants were over the age of 18, from the host countries (UK, Bangladesh, Indonesia and Vietnam).

TABLE I. COMPOSITION OF GROUPS

Type of participant	Number
Academia	15
Industry professional	5
Governmental Organisation	5
Non-Governmental Organisation (NGO)	5

The workshops took place at the premises of partner Universities; University of Warwick (UK), Ho Chi Minh City University of Technology (Vietnam), Gadja Mada University (Indonesia) and University of Dhaka (Bangladesh).

Prior to the beginning of each workshop the participants were orally informed about the topic of debate and were given hard copies of a participant information leaflet to read carefully for 10 minutes.

The participants, prior to the start of the session, were informed that the data are anonymised and kept confidential, and they are not going to be named in any report or publication. They were given to fill in a written consent form and they were allowed to withdraw at any time during the research activity.

Ethical approval was granted to the activities described herewith by the University of Warwick's Biomedical and Scientific Research Ethics Sub-Committee (REGO-2019-2341).

Each practice-dialogue workshop lasted 3 hours. Participants were asked to answer a set of questions as given in Table II. Formal anonymous feedback were elicited.

TABLE II. Questions of practice-dialogue workshops

No	Question
1	What is Humanitarian Engineering?
2	Name 5 humanitarian challenges in your country.
3	Name 5 humanitarian challenges in (other) Asian Countries (state the challenge and the place).
4	Are humanitarian challenges being addressed by current graduate engineering curricula? If yes, how?
5	What do you think makes a 'good' engineering programme?
6	What is the level of collaboration/involvement of industry and other local actors (NGOs, communities, policy makers etc.) in delivering and informing current engineering programmes for tackling humanitarian challenges?

IV. Collected Data And Discussion

The collected data are presented and discussed in the sections below.

A. *What is Humanitarian Engineering?*

In this question there seems to be a consensus across all countries (and participants) on what humanitarian engineering is, suggesting that it is engineering related to building safe communities, shaping sustainable societies, and directing resources specifically towards tackling humanitarian challenges. In terms of engineering education, it suggests the need for community-based curricula incorporating technical and social aspects. Overall the participants seemed to define the term as some sort of development, helping to solve global issues, through community and social inclusion.

B. *Name 5 humanitarian challenges in your country.*

In this question, there seems to be more variation in the collected data since nineteen different challenges were

identified by the participants. Common challenges in the three Asian countries seem to be the climate change, pollution and waste management. In the UK, emphasis is given to energy, health, poverty, sustainability and gender equality, suggesting that there seem to be shared concerns as in the Asian region around the themes of health and environment, in their broad sense.

Table III summarises the most popular 5 humanitarian challenges collected for each country of research.

TABLE III. CLASSIFICATION OF HUMANITARIAN CHALLENGES

Country	Humanitarian Challenge
UK	#1 Energy (related to green house emissions)
	# 2 Health
	#3 Poverty (related to increasing numbers of homelessness)
	#4 Sustainability
	#5 Gender equality
Vietnam	#1 Climate Change and its effects (floods, typhoons, drought, landslides, erosion, storms, deforestation, flash floods, sea level rise and inundation)
	# 2 Food and related themes (environment, health, security, culture)
	#3 Transportation
	#4 Air and water pollution
	#5 Poverty
Indonesia	#1 Water and sanitation
	# 2 Floods
	#3 Waste management
	#4 Wildland fire
	#5 Earthquake
Bangladesh	#1 Climate Change and its effects (floods, typhoons, drought, landslides, erosion, storms, deforestation, flash floods, sea level rise and inundation)
	# 2 Air and water pollution
	#3 Health
	#4 Refugee management
	#5 Waste management

C. Name 5 humanitarian challenges in (other) Asian Countries (state the challenge and the place).

The participants were asked to indicate 5 humanitarian challenges in (other) Asian Countries and state both the challenge and the place where it appears to be critical. Table IV gives classification of the most popular 5 humanitarian challenges identified in Countries around the world. There seems to be a consensus between the participants in the various Countries that in SE Asia, the effects of climate change and its links to natural disasters are of critical importance. The list of stated challenges is further extended with corruption, human trafficking, religious conflict and terrorism.

TABLE IV. CLASSIFICATION OF HUMANITARIAN CHALLENGES IN OTHER ASIAN COUNTRIES

Country	Humanitarian Challenge
Japan Philippines Thailand China Bhutan	#1 Natural disasters (tsunamis, earthquake, erosion, volcanic eruption)
Nepal Malaysia	
India China	#2 Population growth (suggesting challenges related to pollution, energy, food and infrastructure provision)
	# 3 Gender equality
Cambodia	#4 Access to education
Nepal	#5 Poverty

D. Are humanitarian challenges being addressed by current graduate engineering curricula? If yes, how?

Participants were asked to commend on whether humanitarian challenges as aforementioned are being addressed by current graduate engineering curricula.

In Vietnam there seem to be different challenges covered in different engineering disciplines with a *'siloed'* approach being evident when mapping content against different engineering curricula. For example, chemical engineering programmes seem to cover aspects of sustainable development, renewable energy technologies and environmental management while civil engineering programmes cover aspects of climate change and coastal defence. Social aspects do not seem to appear strongly in the current curricula, with the programmes focussing mainly to technical disciplinary content. An interdisciplinary approach seems to be needed across engineering curricula to break down existing *'silos'* that prevent holistic solutions to humanitarian challenges and an integrated context of knowledge and understanding.

In Indonesia, participants claim that a number of humanitarian challenges are discussed more or less in the current engineering curricula via specific relevant modules, field courses and dissertation projects, depending on the academic focus of each programme. A number of participants suggested that stronger emphasis should be uniformly made throughout the curricula across all graduate engineering programmes, regardless of the disciplinary content. There seems to be here the suggestion that the delivery methods need to be modernised and refreshed for the expected learning outcomes to be effectively met. Problem-based, interdisciplinary learning supported by enhanced technology appear to be critical enablers.

In Bangladesh, it seems that current engineering curricula cover humanitarian challenges mainly by covering topics, on an ad-hoc basis, like water resource development, coastal zone management and climate change. It is appreciated that there needs to be extensive improvement in introducing interdisciplinary learning spanning from engineering to sciences and social sciences to ensure the development of higher order skills to graduate engineers. Social, cultural and ethical awareness seem to be critical factors to be included in engineering curricula for tackling humanitarian challenges.

In the UK, the participants suggested that humanitarian challenges are addressed in engineering curricula via specific module content alongside with project and problem-based activities. Students are participating in interdisciplinary, problem-based activities where they are expected to create synergistic connections between different disciplines and compile own experiences for solving complex problems covering aspects of sustainability, resources management, ethics, social and cultural implications. Students are expected

to integrate ideas from arts, sciences, social sciences and engineering into a cohesive design solution.

E. What do you think makes a 'good' engineering programme?

The participants were asked to describe what a 'good' engineering programme looks like in terms of content, assessment and delivery.

In Vietnam, 14% of the participants claimed that '*a good engineering programme involves practical, innovative and interdisciplinary curriculum'* and another 14% claimed that a programme is regarded as '*good'* if accredited by relevant Professional, Statutory and Regulatory Bodies. Furthermore, '*facilities'*, '*human resources'*, '*extra-curricular activities*, '*community-based projects'* and '*technical and non-technical content'* seem to be of equal importance with 7% of the participants agreeing on that for each item. The remaining 37% was linked to the delivery of the programme via practical activities i.e. field work, industry placements and internships, and opportunities for students to get involved to research.

In Indonesia, 23% of the participants supported that *'a good engineering programme needs to be oriented towards current global issues'* and 18% of the participants mentioned that *'having fruitful links with industry indicates an effective programme'*. In the same Country, the perception is that *'an engineering programme would be better if it enables five other aspects: concise technical and non-technical learning outcomes, practical skills, innovation and entrepreneurship, communication skills and humanitarian – community-based engagement'* which each aspect individually contributes by 9% each. The remaining 14% of the participants made the argument that *'an engineering programme can be perceived as good, if it enables interdisciplinary learning and engagement with a number of stakeholders such as policymakers, industry, and communities'*.

In Bangladesh, many responded that community-based projects (20%), infrastructure development (14%), waste management (4%), academia-industry interaction (10%), practical and innovative activities (19%), interdisciplinary activities (14%), and technology-enhanced learning (19%) are the contributors to a *'good'* engineering programme.

In the UK, it seems that a *'good'* engineering programme is associated with involvement of a number of stakeholders to the creation and delivery of the content such as industry professionals, non-government organisations, governmental organisations and communities. Real-life experiences seem to be rather important in graduate engineering education as enablers of '*optimising solutions to benefit the largest possible number of people'*, *'using resources in a mindful manner'*, '*having social awareness'*, and '*ensuring adaptability and flexibility when working on complex multi-faceted problems'*. This suggests programmes more in tune with interdisciplinary, problem-based learning and creative learning environments where students act as co-creators of knowledge.

F. What is the level of collaboration/involvement of industry and other local actors (NGOs, communities, policy makers etc.) in delivering and informing current engineering programmes for tackling humanitarian challenges?

In this question, there seems to be a concensus among the Asian participants that there is some level of collaboration with industry and other stakeholders. There also seems to be the opinion that industry is stronger involved, compared to other stakeholders, to academia and engaged in a number of ways in supporting the design and delivery of engineering programmes. Engagement with other stakeholders (local factors) seems to be weaker and an area for future improvement. Fig. 1 shows the engagement of industry and other local factors in delivering and informing graduate engineering programmes.

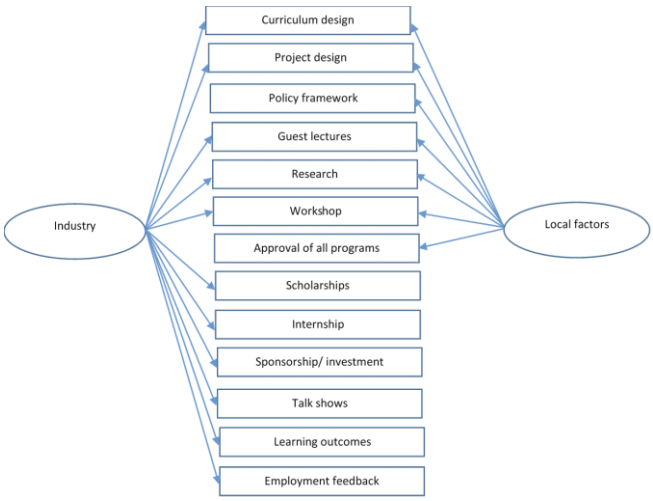

Fig. 1. Engagement of industry and local factors to the delivery and design of current graduate engiueering programmes in Asian Countries.

In the UK, there seem to be strong links to industry and other stakeholders via a number of ways. Students engage and are enthused by authentic and relevant engineering experiences. A primary vehicle is projects spread throughout the engineering programmes for developing skills and encouraging active learning. Industry is working closely with academia in framing the skills graduates need. Wherever possible industry delivery is encouraged for enhancing the students' transferable and employability skills. Students have the opportunity to attend a wide range of practical activities and experience the workplace either by taking a year in the industry or vacation internships, as a means to forming professional engineers. Key features of the UK programmes in this respect involve field courses and community-based activities, where students have the opportunity to experience real-life working conditions in the field. Nonetheless, these courses instil enthusiasm and sense of belonging within the engineering community. Modern engineering challenges and the global issues that most enthuse the students are not to be solved by any one discipline, but instead by teams of engineers from across the disciplines and non-engineers, bringing together their skills and expertise to create innovative solutions. UK engineering programmes are preparing the students for this with appropriate experiences, such as undertaking complex projects in interdisciplinary teams. Programmes are co-created and co-delivered by academics and industry professionals which form the programme's industrial advisory board while the students

have also opportunities to participate to industry-led mentoring and training schemes. Industry partners offer scholarships, placements, internships, invited lectures, seminars, workshops and visits to their premises for the students to experience the workplace.

It is appreciated by the majority of the participants in all Countries that engagement with industry and other stakeholders is vital and should be strongly emphasized in the strategic plans, vision, core values and culture of the higher education institutions.

V. Conclusions And Reflection

Engineering education programmes in Asia are governed by traditional methods of teaching, learning and assessment (lacking creativity and innovation), lack of equity and gender disparity (e.g. 1 out of 20 women graduates, graduate in engineering) and have minimum relevance to real-life problems and global challenges [2][3][8]. What is needed are innovative, inclusive, interdisciplinary graduate engineering programmes i.e. by incorporating concepts such as humanitarian engineering, which contribute to students' global awareness, via a programme of real life-focused activities starting at first arrival and continuing beyond graduation and into their engineering professions.

Findings from this study indicate that humanitarian engineering is perceived as the application of engineering to alleviate poverty, ensure sustainability to communities and tackle global challenges. The challenges identified by the participants as related to humanitarian engineering varied by ethnic origin. Humanitarian engineering aspects do not seem to be directly embedded to current curricula in Asia, mainly attributed to still weak engagement with the industry and local communities for offering real-life experiences to students. By integrating humanitarian engineering, a number of key professional attributes shall be enabled, involving the ability to manage resources more effectively, solve complex problems which require interdisciplinary inter-professional competencies and demonstrate team working and communication skills; all of those being highly appreciated by employers.

From this study, there seems to be consensus among the participants that engineering must be viewed as a profession that incorporates social, financial and environmental responsibility. Engineering education programmes should guide students through a holistic process of inquiry and cultivate creativity, innovation, reflection and critical thinking.

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