# EDUCATING FOR INTEGRITY: BLENDING THE LIBERAL ARTS AND HUMANITARIAN ENGINEERING

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## ABSTRACT

In 2005 the Carnegie foundation published the second edition of William Sullivan's work on integrity. A guiding idea behind this project is that professionals in a variety of fields will face conflicts that cannot be neatly or easily resolved. A professional with integrity manages these conflicts ethically, wisely, and well. This also implies a need for innovative education initiatives to enhance impact for society and especially the vulnerable and underserved. Humanitarian engineers fulfil this need to be prepared for professional lives of integrity. Moreover, in the coming years, education for societal impact places them at the intersections of countless competing demands, including climate change, mass migrations of people across the globe, rising living and resource costs, just to name a few. This requires interdisciplinary and transdisciplinary perspectives to education and innovation. Integrity and ethics are key virtues influencing conception, design, implementation, and operationalisation of education tailored for integrity, that is a cornerstone of many ethical traditions, and an aspiration of a liberal arts approach to education. In this paper, we explore two ways of connecting liberal arts education (using as reference a programme taught in US and a programme taught in EU) to new education initiatives in humanitarian engineering education. The overarching goal is to create innovative education programmes for a new crop of humanitarian engineers that prepares them for a professional life of integrity while creating broader impact for underserved and vulnerable persons. Specifically, we postulate that integrity as taught within a liberal arts education can positively contribute to humanitarian engineering education, and better prepare future humanitarian engineers to approach societal problems from the broadest possible perspective, while co-creating innovative technological solutions for humanity. The role of challenge-based education for co-innovation and co-creation within the CDIO cycle is underscored in this process.

## KEYWORDS

Engineering Education, Humanitarian Engineering, Liberal Arts, Learning Experience, Sustainable Development Goals 4 – Quality Education

## INTRODUCTION

Eradication of poverty and supporting underserved communities are mentioned as important targets of the United Nations Sustainable Development Goals (United Nations General Assembly, 2015). Economic development is not only based on technological needs, but also on effecting behavioural change. As such, education is central to reaching these goals. Furthermore, effective governance; reliable, affordable first-class technology; rural yet world-class affordable healthcare are key elements to improve the economic outlook of underserved communities. Furthermore, humanitarian crises of the 21st century are complex in nature and affect huge portions of the global population - often affecting the living standards of marginalised, discriminated, or underserved groups of people. To address the scale and complexity of these problems, which afflict more than 10% of the world population, it is necessary to train professionals able to bring about effective solutions.

We believe that integrated social-technical solutions are needed to properly tackle the humanitarian challenges in areas such as resilience, infrastructure, and the environment. Problem-solving in situations of serious structural or accidental resource limitations requires frugal engineers, to serve immediate vital or fundamental human needs. Integrating social science with engineering ingenuity provides the basis for socio-technical systems thinking, core to developing sustainable innovation solutions for tackling global challenges at a local scale. We also believe that technical solutions to challenges should be equitable. Underserved communities are everywhere in the world, and it is important that there is equity in access despite resource limitations. In this light, there is a need for a dedicated engineering profession with an interdisciplinary character that can operate in different fields facing complex challenges. In this paper, we explore how liberally educated students are stimulated towards professional integrity and how their education can bring value to the humanitarian engineering (HE) field.

Though this raises important questions: 1) how do we ensure we conceive, design, implement and operationalise new education programmes to train the next generation of humanitarian engineers to innovative technological solutions for the vulnerable and underserved?, 2) how do we leverage on integrity and ethics primarily the core of liberal arts (LA) education, into the conception, design, implementation and operationalisation?, 3) what role does new initiatives, such as challenge-based education enhance embeddedness of ethics and integrity while co-creating technological solutions for the underserved?

We propose a three-phase methodological approach: 1) starting with exploring integrity and ethical elements in LA education, focusing on LA education in the Netherlands and the US. 2) embedding LA education aspects to the structure of a new HE programme. 3) Implementing a pilot case in a new master course in HE.

## LIBERAL ARTS EDUCATION

### *University of Twente (The Netherlands)*

Ten universities in the Netherlands adopted the American model of LA education. Unlike other university students in the Netherlands, LA students are not being prepared for a specific profession, instead, they develop broad knowledge and skills that they can apply to various complex problems that they will encounter in their careers (Doan & Huntington, 2017). Liberal Art programmes are selective, and they aim for curious, ambitious, and self-driven students willing to create a large societal impact through their careers.

The degree structure of the Dutch LA programme varies, but what all programmes have in common is education in “themes” that aims to address the most pressing global challenges.

However, each university offers a different level of flexibility depending on the balance between compulsory and elective courses (Doan & Huntington, 2017). For example, University College Twente (UCT) curriculum is fully based on a self-designed and self-directed learning concept which allows students to create their own study programme based on their interests. Each UCT module is built around a central theme (see Figure 1). Within each module, there is a fixed interdisciplinary team project in which students apply their acquired knowledge to a real-life challenge and manage ethical and integrity aspects during their study duration. Besides the project, students have the freedom to select courses that contribute to their individual personal and professional development. This innovative project-based learning method is part of the Twente Education Model (TOM) which is a unique way of studying at the University of Twente (University of Twente, 2022a). Finally, differently from most of the traditional BSc programmes, UTC students do only receive feedback and qualitative assessments without grades.

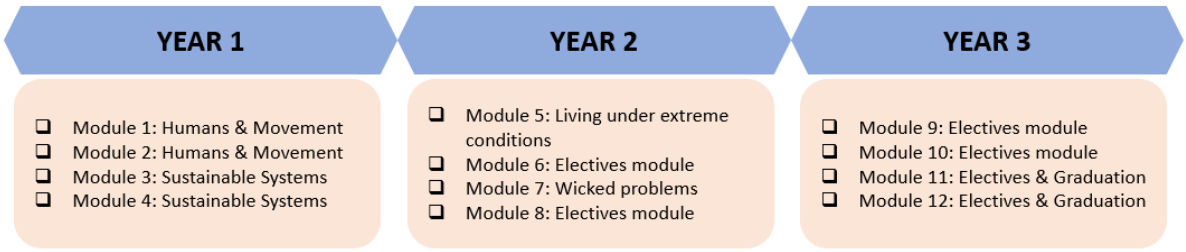


*Figure 1: Online brochure: Bachelor of Science, University College Twente, adapted (University of Twente, 2022a)*

What makes UTC unique in comparison to other University Colleges is the addition of „technology" to the LA education which allows the students to look at the impact of technology on society. Therefore, good proficiency in mathematics and science (Physics/Chemistry) is needed for acceptance in the programme (University of Twente, 2022b) which is an exception among Dutch LA programmes. More specifically, the courses are designed to challenge students to navigate societal problems associated with working with communities (e.g., in modules 5 and 8), while acting as ethical professionals.

It is apparent that LA graduates, who are interested in contributing to the wider society (Doan & Huntington, 2017), have the potential to become future engineers that can work in a complex cultural, political, and economic context and co-create appropriate humanitarian solutions. In line with this, the internal data of the University of Twente shows that the largest number of UTC graduates who continue their education at the University follow the master's programme in Sustainable Energy Technology (5,5 % of all graduates between 2017-2021). This unique and innovative two-year programme trains student to become "*a sustainable technology pioneer that oversees the whole picture*" through mandatory courses on technology and sustainability or social entrepreneurship (in the 1st year) and several electives in the 2nd year (University of Twente, 2022c). The idea of defining together with users or communities' challenges (use-cases) is an important starting point to innovative solutions tailored for the underserved. This idea is embedded in the HE education, through innovative challenge-based education approach.

***St. Lawrence University (United States)***

LA education in the United States aspires to educate the whole student (Nussbaum, 1998). It is often distinguished from a college education that fits a student into a predetermined career track. But focusing on career outcomes misses the fact that employers often look for skills that LA students graduate with, and the fact that just because a degree program is marked as pre-

professional, it does not mean that graduates from these pre-professional programs are more employable than their LA counterparts (Farrington, 2019).

What distinguishes a LA education from its alternatives is an approach to curriculum that emphasises exploration and integration. Most LA colleges in the United States will have what is called a "general education curriculum." In addition to specialising in a major field of study– e.g.: Economics, Philosophy, Physics, Engineering–students will also have to take courses that represent a range of disciplines. At St. Lawrence University, for example, students are required to take a course in the arts, a course in the humanities, a course in the social sciences, and a natural science course with a lab. They will also have to take a course that teaches environmental literacy, and a course that teaches quantitative literacy. Finally, students will have to meet a diversity requirement, which can be fulfilled through the study of a foreign language, study abroad, and/or courses on human diversity in its myriad forms (St Lawrence University, 2022). Students have a great deal of freedom as to how they meet their general education requirements, but every student must graduate with a major and meet the general education requirement.

Many of the best undergraduate colleges in the US follow a LA approach, and these colleges are highly selective. But there is a range of colleges that follow the LA model in the United States, from colleges that accept less than 10% of the students who apply to colleges that accept a majority of students who apply. Outcomes for students from across LA colleges also vary, with students from the most highly regarded colleges gaining admissions to elite graduate schools and highly-coveted positions in a range of industries.

Regardless of market position and status, LA colleges are looking for new ways to connect graduates to careers and to meaningful work after graduation. With this in mind, we see important work to be done in connecting more LA graduates to HE. For example, students with strong technical training will also have a broad general education, which will make it more likely that they will bring flexibility and intellectual humility to the work of responding to humanitarian issues (Arshad-Ayaz, Naseem, Mohamad, 2020). As well, when LA students consider ways to fulfil their diversity requirements through study abroad and other experiences, these are prime opportunities to expose them to HE. Additionally, LA colleges can expose their students to challenge-based learning (CBL) experiences in their first year. This exposure may help them see the importance of HE while they still have time to select a major field of study. Finally, LA colleges already have tracks that help students earn engineering degrees. In addition to building tracks into traditional engineering fields, work can be done to establish HE tracks (St. Lawrence University, 2022b).

### *Shared characteristics of liberal arts education*

We identified several characteristics that LA students and graduates from the Netherlands and the US have in common.

It is apparent that the focus of LA education in both countries is the development of students´ competences that are needed for succeeding in today´s job market (*21st-century skills*). These competences are very often not job specific. Although a narrow discipline education is not the main focus of LA curricula, the students throughout their studies get acquainted with a *range of disciplines*, including for instance physics, and chemistry but also arts, and humanities...What LA graduates in the Netherlands and the US also have in common is their *flexibility*, *self-motivation* and ability to look at current global problems from *different perspectives* and work in collaboration with various *stakeholders.*.

Such a combination of 21st-century skills and knowledge of disciplines is essential for developing professional integrity. Students participating in an integrity education, such as LA

education, are capable of making complex ethical decisions and contributing to society in a meaningful way.

## MASTER´S IN HUMANITARIAN ENGINEERING

A humanitarian engineer should be trained to *flexibly* navigate and function in a range of diverse cultural and political systems; the technologies will be co-created with community actors. Moreover, HE academic professionals should be equipped with skills to research, design, organise and manage structural or incidental appropriate technologies and innovations to overcome resource limitations. This requires ingenuity and a structured *problem analysis* method involving social-technology disciplines explicitly involving communities, government and non-government actors and users of the appropriate technologies. This extends to analysing the needs of *stakeholders* and the unique local contextual awareness to find and adapt technical solutions to suit local needs.

The prospective student has a *societal impac*t high on their list and wants to make an impact for underprivileged communities and/or communities that face resource limitations in any which way. They are *self-driven* to make a change for the better, want to fight for equity and feel it is their responsibility to do so.

The Humanitarian Engineering master´s programme at the University of Twente will offer students the option to focus on three domains within the framework of HE. These focus domains are on immediate assistance (*Humanitarian Aid Engineering* – i.e: quick solutions for water supply, communication connection, first demining action, flexible and modular facilities); long-term planning and capacity building (*Resilience Engineering* – i.e: maintenance planning, education facilities, robust infrastructures) and implementation/value creation from technology (*Responsible and Sustainable Entrepreneurship* – i.e: job creations, small scale economy planning). This approach will help to create professionals that will be specialised in different moments of a humanitarian crisis, characterised by unique skills. The mentioned three focus domains will have in common the appropriate technology approach.

### *Structure of the future programme*

The Master of HE will be an interdisciplinary programme combining technical/engineering disciplines of Mechanical, Civil Engineering, Social and Governance disciplines, Business administration, and Economics and Geo- and Spatial Sciences. As humanitarian engineers, students will be trained to co-create appropriate technologies together with all the involved actors, including underserved communities. The technologies will suit local needs related to, for example, but not limited to, water extraction and supply, sanitation, innovative energy solutions for off-grid communities, civil infrastructure (including low-cost bridges and roads) and appropriate healthcare technologies.
The programme will use the concept of CBL as a guiding framework. Multiple societal challenges form the backbone to teach teams of students structured problem-solving approaches and design appropriate engineering solutions in areas as diverse as water and sanitation, healthcare, infrastructure, and institutional design. The students will collaborate with stakeholders to frame the problems based on local needs. In the process, they reflect upon - amongst other things- the impact of stakeholder culture, opportunities and risks of solutions, the effect of variations in stakeholder cultures on the provided solutions and pitfalls in implementing suggested solutions.

The programme will require to have an engineering or technical background. Table 1 gives a possible setup of the future programme. The first year will offer opportunities for the candidates to be exposed to core social-governance-related courses to complement technical aspects, starting with Introduction to Humanitarian Engineering. This includes courses such as Participatory data acquisition, Culture in Technology, Life-cycle strategies, Ethical

Entrepreneurship, Resource-limited Engineering, Cross-cultural Behaviour, Global Development Forecasting and Governance. During the first year, the student will also have the opportunity to choose elective courses on dedicated topics (such as water management, healthcare etc..) within the three highlighted domains.

The programme's second year will be dedicated to elective courses and a master's research thesis. Students will be encouraged to pursue part of this work abroad and gain a more globalised scope of societal challenges. The programme will focus on case studies of real-life problems facing resource-constrained communities developed in collaboration with partner universities where the communities reside. This essential part will prevent the students from working on hypothetical problems in order to find hypothetical solutions that do not have real applications.

*Table 1: Possible Humanitarian Engineering MSc programme setup*

| YEAR 1 (60 ECTS) | | | | |
|---|---|---|---|---|
| | **Q1 (15 ECTS)** | **Q2 (15 ECTS)** | **Q3 (15 ECTS)** | **Q4 (15 ECTS)** |
| **Course A** | Introduction to Humanitarian Engineering (compulsory, 10 ECTS) | Humanitarian Aid (compulsory, 5 ECTS) | Resilience Engineering (compulsory, 5 ECTS) | Responsible and Sustainable Entrepreneurship (compulsory, 5 ECTS) |
| **Course B** | Science and Humanitarian Engineering (compulsory, 5 ECTS) | Elective course (elective, 5 ECTS) | Elective course (elective, 5 ECTS) | Elective course (elective, 5 ECTS) |
| **CBL project** | | Humanitarian Aid (compulsory, 5 ECTS) | Resilience Engineering (compulsory, 5 ECTS) | Responsible and Sustainable Entrepreneurship (compulsory, 5 ECTS) |
| **YEAR 2 (60 ECTS)** | | | | |
| | **Q5 (15 ECTS)** | **Q6 (15 ECTS)** | **Q7 (15 ECTS)** | **Q8 (15 ECTS)** |
| | 3 Elective courses (3x5 ECTS); or<br>Elective course + Master Insert (5 ECTS + 10 ECTS); or<br>Internship (15 ECTS) | Research Proposal (compulsory, 5 ECTS) | Master Thesis (compulsory, 40 ECTS) | |

### *Application case examples*

As a pilot case, a new course in “Introduction to Humanitarian Engineering” was initiated for 5 European Credits (ECTS) that equals to 140 study hours. The design of the course integrates a challenge-based education core, and integrity (and ethical) perspectives taught through several lectures on stakeholder engagement and assessment. The design of the course closely reflects the CDIO cycle, and a use-case of the ‘Agribox’ project developed at the University of Twente implemented throughout the course. The ‘Agribox' is an innovative classroom for smart agriculture education that consists of a retrofitted shipping container housing food production technology, including hydroponics and algae production. The course, which reflects the structure of the HE education proposed in Table 1, focuses of education engineers to work ethically with vulnerable communities to co-innovate technological solutions to address challenges such as water and energy access. At the design phase, learning goals are developed addressing the HE phases: from conceiving needs of societies, to co-designing and implementing appropriate technological solutions together with local communities. A CBL approach focusing on the ‘Agribox’ is implemented in the course, and innovative assessment is considered to evaluate the learning goals of the course. Though under implementation, the pilot course provides valuable insights on implementing the CDIO cycle, but importantly, embedding learning goals of ethics and integrity taught in LA programmes - and translated to new educations programmes aiming at broadening societal impact.

## DISCUSSION AND CONCLUSION

LA graduates in the Netherlands as well as in the US seem to be well-positioned to enter HE programs that focus on creating ethical and sustainable solutions to complex global issues. Specifically, they receive education that stimulates them to obtain knowledge and skills that are seen to be crucial for their professional life which demands that they demonstrate the highest levels of integrity while co-creating or co-innovating technological solutions for underserved and vulnerable actors in the society. By being educated for integrity, students also shape their individuality and learn how to be self-driven individuals with a sense of responsibility and the capability of making ethical decisions.

In this paper, we identified a set of skills that LA graduates in the Netherlands and the US are equipped with and are essential for solving HE challenges. These skills and their relevance to HE education are depicted in Figure 2.

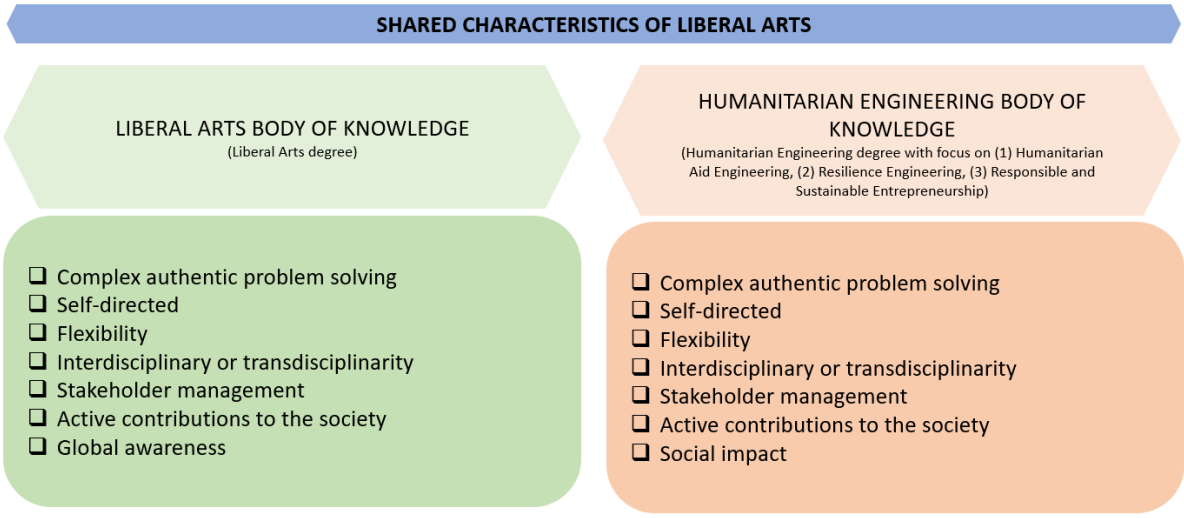


*Figure 2: Comparison of common knowledge and skills between Liberal Arts and Humanitarian Engineering education*

Through the master programme in HE, we aim to train future engineers to see societal challenges from multiple perspectives, analyse the needs of stakeholders in a unique context before drawing conclusions and develop appropriate social-technical solutions for and with underserved and marginalized communities. We believe that the LA approach to HE is a crucial key to do so, and therefore, the programme curriculum includes aspects of LA education. To mention a few, students will work on complex authentic cases (challenge-based learning framework) that require interdisciplinary or transdisciplinary collaboration and the involvement of involved stakeholder, or they will be given the flexibility and freedom to select electives based on their personal and professional interests.

Because the HE master programme at the University of Twente has not yet been launched (the first class will start in 2025), no data are available to support our hypothesis about blending LA education in HE. For that reason, the outcomes of this paper need to be interpreted with caution.

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**Peter Chemweno** is an Assistant Professor in Advanced Manufacturing, University of Twente. He graduated with a PhD in Mechanical Engineering, from KU Leuven, Belgium in 2016. His doctoral work focused on developing maintenance decision support models for managing failure risks of thermal power plants. For recognition of his PhD work, Peter emerged as the Belgium winner and nominee for the PhD thesis excellence award. After his PhD, Peter worked as a postdoctoral researcher at KU Leuven and diversified his research to focus on the assessment of safety hazards of collaborative robots. During his post-doc stay, he developed innovative generic models for anticipating the safety hazards of collaborative robots.

**Alberto Martinetti** is an Associate Professor in the group of Humanitarian Engineering within the Department of Design, Production and Management. He worked for the Polytechnic of Turin and the University of Turin. He holds a Master's degree in Geo-resources and Geo-technologies Engineering (2009) and a PhD degree in Environmental and Land / Safety and Health at the Polytechnic of Turin (2013). In his current position, he supervises BSc, MSc and PhD students.
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