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ARTICLE

Humanitarian engineering education fieldwork and the risk of doing more harm than good

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ABSTRACT

Universities throughout the world are realigning engineering education by integrating the impact and importance the profession has on humanity, society and the natural environment. Amongst western universities it is common practice for the engineering programs to have ethics and sustainability embedded within most professional practice courses. Western universities are now understanding the important role cultural, social and emotional intelligence play in producing holistic 21st century engineers. Universities are supporting and fostering fieldtrips to resource-constrained communities, exposing students to real-world problems and finding solutions not necessarily typical in western environments. This, to a certain degree, has helped promote the concept of the Humanitarian Engineer. However, many activities run the risk of disempowering communities and incorrectly promote neo-colonialism as a positive concept to students: the exact opposite of what universities should be striving to achieve. This paper explores the concept of voluntourism and the need for holistic and sustainable solutions for universities to produce culturally, socially and emotionally intelligent engineers with a strong depth of technical knowledge. The paper provides case studies of different programs, highlighting different methods of service-learning and community empowerment. The paper provides a framework to assess program suitability to produce holistic 21st century engineering graduates.

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Service-learning; voluntourism; experiential learning

1. Introduction

1.1. Developing the 21st century engineer

There is a growing demand for universities to provide graduates that are global citizens who are socially responsible and have emotional intelligence. Within the engineering education sector, there is a push for engineers to go beyond mathematics and science (Bordogna 2001; Miller 2017). For example, the perspective from the University of Colorado, Boulder is that in the 21st century,

> engineers are called to be change-makers, peacemakers, social entrepreneurs, and facilitators of sustainable human development (Amadei 2018)

Pascail (2006) presents a similar perspective in that engineers must combine the technical and human demands and concepts to be effective in their employment. This is supported by Ravesteijn, de Graaff, and Kroesen (2006) highlighting that communication skills, including social and cultural awareness, and the ability to '*communicate on different levels of facts, values and emotions*', are essential for engineers to succeed.

These 21st century engineering graduate attributes are reflected in professional engineering bodies, such as Engineers Australia, the Institute of Civil Engineers (UK), and the Accreditation Board for Engineering and Technology (ABET in the US) requiring professional engineers to be socially and environmentally aware. A detailed analysis of these competencies from various agencies is given in Smith et al. (2019). For the Australian context of Engineers Australia Stage 1 competencies (those required to enter the engineering profession) include:

- 1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline.
- 2.1 Application of established engineering methods to complex engineering problem solving.
- 2.3 Application of systematic engineering synthesis and design processes
- 3.3 Creative, innovative and pro-active demeanor
- 3.6 Effective team membership and team leadership (Engineers Australia 2011)

To achieve these competencies, engineering education should therefore be holistic and include values, beliefs and consciousness of self and environment. This is

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reflected at the College of Engineering, Purdue University, where they have three pillars in their undergraduate education program to develop the 'Renaissance Engineer' (Purdue University 2019). These pillars are broadly: abilities, knowledge areas, and quality. Within each pillar are some key attributes, which go beyond technical skills and knowledge. These attributes, which do not detail all the requirements within the pillars, listed as:

(1) Abilities (includes leadership; teamwork; communication; decision-making; work effectively in diverse & multicultural environments; work effectively in the global engineering profession)
(2) Knowledge Areas (includes open-ended design & problem solving skills; multidisciplinary with and beyond engineering; integration of analytical, problem solving, and design skills.)
(3) Qualities (includes innovative; ethically responsible in a global social, intellectual and technological context).

These attributes can be taught at a rudimentary level in a lecture theatre and even online lectures. Many can be taught together in stand-alone courses under a generic title such as 'professional practice'. However, providing genuine capabilities in these fields, and thus producing renaissance engineers for the 21st century, requires more than just lectures. It requires experience and practice. To help address this requirement there are two pedagogical tools that can be used: experiential learning and service-learning.

1.2. Experiential learning and service-learning

Experiential learning is an education process whereby the experience and the reflection of that experience provides the learning platform (Felicia 2011). According to Sigmon (1979), service-learning is an umbrella term for 'voluntary and experiential education programs'. Therefore, service-learning can be categorised as a subset of experiential learning, which requires the experience to be in service to the community: people learn while helping a community.

Within engineering education, Bielefeldt and Lima (2019), argue that service-learning is not only suitable for teaching engineering design processes and the human-centered design approach, but service-learning is 'ideal' in educating global citizens. In a university's quest for educating global citizens, service-learning becomes a viable and vital option.

There are numerous benefits from service-learning. Slivovsky et al. (2003), Al-Khafaji and Morse (2006), and Coyle, Jamieson, and Oaks (2006) highlight benefits including students developing greater self-awareness, cultural sensitivity, teamwork, and empathy. Jiusto and DiBiasio (2006) claim a benefit to students of service-learning includes higher readiness for self-directed and life-long learning. Furthermore, Al-Khafaji and Morse (2006) also found a strong desire in students to use technical skills to promote peace and human development. These attributes are aligned with those of the 21st century engineer.

Beyond the individual graduate engineer, there is a growing societal demand for increased diversity in engineering teams. This includes diversity in gender, sexuality, socio-economics, age, religion, ethnically, and people living with disabilities (their own or that of a family member). As shown by Jessup, Sumner, and Barker (2005), Coyle, Jamieson, and Oaks (2006), and Selingo (2006), service-learning is popular with women. Daniel and Brown (2018) showed that a long-running service-learning program run by EWB (Australia) has non-quota enforced percentage of approximately 45% women out of more than 1000 students. Interestingly, Bauer et al. (2007) shows a greater awareness to community service from female students compared with male students. Service-learning may therefore help attract and retain female engineering students at universities, it may improve the educational experience of those female students, and society may gain more benefit from female students undertaking service-learning programs compared with male students. Beyond gender diversity, Desmond, Stahl, and Graham (2011), show a link between service-learning and diversity education in a broader context.

Much good can come from such a system when mutual benefit is a focus, and according to Bielefeldt and Lima (2019) the process is to engage with stakeholders who do not have a technical background. The justification for this selection criterion can be seen in Sigmon (1979), where a focus on mutual benefit and capacity building is given leading to three principles of service-learning, being:

(1) those being served control the service(s) provided;
(2) those being served become better able to serve and be served by their own actions;
(3) those who serve also are learners and have significant control over what is expected to be learned.

These principles can secure the moral purpose of service-learning. However, critically and cynically, reference can be made to the proverb from 12th century French abbot St Bernard of Clairvaux in that 'the road to hell is paved with good intentions'. It is possible that the intent to help actually hinders. It is argued here that the risk of unintended hindrance for service-learning within engineering education is high.

Service-learning ***should*** be mutually beneficial to all parties involved. It ***should*** provide a platform for

reciprocal learning. It ***should*** help produce graduates with greater empathy, greater cultural awareness, and greater emotional intelligence. It can also reinforce knowledge from other courses. Unfortunately, a consequence of service-learning being formalised in an educational environment is that learning objectives are applied and student satisfaction metrics are measured. Attempts to link and apply learning from other courses/subjects are made, thereby reinforcing knowledge and provide context to what may be more theoretical topics. This fits within the philosophy of constructivism (Piaget 1971), and hence educators have greater justification for the push of service-learning. Students learn more, gain context to their studies, and are happier because they have 'helped'. Everyone seems happy. However, the reason this is unfortunate is that the focus shifts away from the principles as detailed by Sigmon (1979). There is no longer a goal of reciprocal learning. The 'customer' is now the student, not the community being supported.

Evidence to support this claim can be seen with more recent analysis of existing service-learning programs. Levesque-Bristol et al. (2010) surveyed over 600 students from 100 courses and 30 disciplines all from one university. Their students were cognizant of their motivations and how they had significantly improved their insight due to their service-learning. An interesting finding was that their service-learning program did not improve a sense of civic skills and did not change the motivation of students. Typically, there is a strong self-selection for service-learning programs, so it may be that motivation of students did not change as the students were already motivated by a sense of civic duty. However, for the purpose of the current work the key point is that, only the student benefits were analysed while community benefits were not mentioned.

A similar detailed study by Cannon et al. (2016) was undertaken for industrial engineering students at Mississippi State University undertaking service-learning at a sweet potato farm. Their results again support general findings that students were able to develop a greater knowledge of engineering topics, improve their communication skills, improve their teamwork skills, and enjoyed their projects. However, there was only one sentence in the 10-page paper about the benefits to the community *'the community partner also benefited directly through the recommendations provided to improve operations at their company'*. There was no elaboration of how the community benefited nor how the researchers came to this conclusion.

Bringle (2005) discusses service-learning as a means to enhance learning outcomes, and foster civic engagement, volunteering, political participation, and intergroup relations in college/university students. Again, there is extensive analyses on student experience and learning and a lack of reported consideration for the communities being serviced.

Berman (2006) promotes service-learning in a similar way, but includes key points for instructors/coordinators in that they should align course goals with community partner goals (therefore providing an initial focus on the community), and involve students in the decision-making process (fostering student reflection and self-evaluation). These align with points 1 and 3 from Sigmon (1979), but do not address the need that '*those being served become better able to serve and be served by their own actions*' a key component which should be considered in all service-learning.

Another definition of (international) service-learning from Bringle and Hatcher (2011) is a structured academic experience in another country in which students;

(a) participate in an organized service activity that addresses identified community needs;
(b) learn from direct interaction and cross-cultural dialogue with others; and
(c) reflect on the experience in such a way as to gain further understanding of course content, a deeper understanding of global and intercultural issues, a broader appreciation of the host country and the discipline, and an enhanced sense of their own responsibilities as citizens, locally and globally."

Contained within this definition, other than organized service activities that address community needs, there is no aspect of reciprocal learning or community empowerment.

It is argued in the current work that the focus of service-learning has shifted to consider the students learning needs above the community, almost to the point of excluding considerations of community benefits. This can be reflected from Furco (2011) highlighting that for some members in the field, service-learning now includes field studies and internship programs as well. It is misinterpreted as experiential learning, rather than a subset of experiential learning where community benefits are provided.

Engineering is an application of knowledge, predominantly but not exclusively science and mathematics. Students are taught that engineers are 'problem solvers' and 'solution generators' when a problem cannot be found. This concept is ambitiously positive, but only when the solutions are holistic and sustainable. If solutions are unsustainable, then the solutions are simple gap-stops in addressing the real problem, and potentially create further problems. Solutions that are not holistic fail to consider the whole system in which they work. Within all of these points, it is critical that engineering solutions are end-user focused. Service-learning needs to be separate from just experiential learning. However, it is

understandable that universities shift focus away from community benefit. As explained by both Huband (2006) and Selingo (2006) the engineering curricula is full. Adding to that curricula can be challenging. In some cases, using 3rd-party providers to run the service-learning, while providing academic credit for courses or required work experience is an appropriate option. However, this option requires an awareness to ensure programs are still service-learning and not just experiential learning, or even voluntourism.

1.3. Voluntourism

The term voluntourism is a portmanteau of volunteering and tourism. It provides an option for those who want to feel like they are contributing to making the world a better place and want to travel and see the world to do both at the same time. It has become common in the tourist industry throughout the world, but in the same way that the blending of service-learning with the basic definition of experiential learning is limiting the focus on community benefits, voluntourism is more focused on the paying tourist, rather than the community being serviced.

An exert from an Engineering For Change blog written by the lead author helps highlight an issue voluntourism:

> A typical example is where relatively well-off citizens from Australia, Europe, or North America travel to an impoverished community in Africa, Asia or South America and help build an orphanage or school. They work from dawn to dusk in sweltering conditions doing manual labor, under the supervision of someone who is qualified, or 'has done the work before.' At the end of the project, there is a new orphanage or school and something for which the volunteers can be proud. There is some sort of opening ceremony and the community shows their thanks for the great and wise intervention and support from western volunteers (Engineering For Change 2019).

Reflecting back on Sigmon (1979), it is unclear if those being served control the service(s) provided. It is clear that those being served are not better able to serve or be served by their own actions. The only point addressed is the volunteers have control over what they learn. In so doing, the voluntourism industry promotes a neo-colonial approach to supporting resource-constrained communities. In regards to engineering education, the combination of industry demands, student expectations, already-packed curricula, and time-poor academics, it is easy to understand how voluntourism in place of service-learning occurs. The remainder of the current paper critiques a number of existing but different systems.

2. Methodology

Based on the concerns raised in the literature review, the authors undertook qualitative analysis with these two questions in mind:

(1) Can experiential-learning and/or service-learning provide a pedagogical vehicle to enact Sigmon's (1979) principles for mutual benefit?
(2) What would a framework look like to assess program suitability to produce holistic 21st century engineering graduates?

To address the research questions for the current study, a variety of educational programs were identified based on three main criteria: students learn new skills, it is immersive, and provides community benefit. The five case studies were chosen because they represent a point of departure of differing pedagogical vehicles. For the qualitative analysis of the case studies a varied methodology as much of the knowledge was obtained through participant observation, personal communication with those running programs and desktop analysis/literature reviews. For both the Engineers Without Borders – Australia (EWB) and Project Everest Ventures (PEV) case studies the lead author was a participant observer, data for the WindAid and Milwaukee case studies was gathered through personal communications with the academic staff and participants and an analysis of their website (WindAid Institute 2019) https://www.windaid.org/about-us/accessed). While the Detroit data and analysis were gathered through desktop research.

Participant observation has long been a popular research method amongst the social sciences and is now becoming a popular method for qualitative studies within the broad field of education (Kawulich 2005). In light of this, the lead author participated in multiple EWB Design Summits and Project Everest Ventures treks. As Kawulich (2005) states, participant observation is a type of fieldwork where the researcher is immersed in the phenomena they are studying and are able to understand the activities, norms, expectations and boundaries which are present. Through this immersion and with the research questions in mind, the lead author was able learn how the programs worked, what were the expectations of the students and the communities and see first-hand what the outcomes were.

Personal communication was a valuable methodological tool used to gain data on the WindAid and Milwaukee cases. The authors have two former students who participated in the WindAid volunteer program and had close correspondence with the organisers of the program. The students shared their experiences and observations and the organisers provided valuable insight into the program. Both the

students and the organiser were able to provide information that directly addressed the research questions. With this mix of research methodologies, the authors were able to analyse the data and answer the research questions.

3. Case studies and analysis

3.1. EWB Design Summit

The EWB Design Summits were established in 2015. The general concept is that (predominantly) engineering students from a range of universities across Australia spend two weeks in a resource-constrained country. The summits have approximately 45 attendees, split into three teams of 15. Each team is supervised by a Facilitator and a Mentor. The Facilitators and Mentors are industry professionals usually with humanitarian/development experience and specific in-country experience.

The two-week period is broken down into the three stages. The first stage, conducted in a large city, students are given lessons on numerous human-centred design, lessons on appropriate (and inappropriate) technology, and relevant language and cultural lessons. Students are given small tasks that involve engaging with community members. The first stage provides the fundamentals of developing solutions 'with' communities, rather than just 'for' communities.

The second stage sees the teams deploy to separate small rural communities for a homestay-like period. During these four to five days and nights, the students and supervisors (plus translators if required) observe, experience, and emapthise with community members. The intent is to identify a range of opportunities and problems that the students could address. Towards the end of the second stage, small design teams are formed to work on identified and specific problems/opportunities. By forming teams early, they have additional time to engage with community members to gather sufficient information and potentially opinions on possible solutions.

The final stage has students reunite at a central location (usually a large city), to work on solution generation and prototyping. At the end of this stage, the students present the solutions to relevant community members. Community members can then do what they wish with the prototypes and ideas.

The EWB Design Summits have successfully educated over 1000 Australian university students in aspects of human-centred design in countries including Cambodia, India, Nepal, Malaysia, East Timor, and Samoa.

These countries are selected as EWB have existing partnerships in these locations. Within the concepts of service-learning, experiential learning, and the risk of voluntourism, the EWB Design Summits do some things very well. The students learn to focus on the end-user in the design process. They gain a greater understanding of diversity, culture, society, and a greater appreciation of local capabilities. They are given the freedom to apply their existing knowledge in a constructivism approach to develop solutions partial with the end-users. At no stage are the students taking away any employment or doing any work that they are not necessarily qualified to do. There is no question of voluntourism. Furthermore, by working in communities where EWB already engage, it strengthens EWB's in-country footprint and helps them continue the ongoing development work. The communities are paid for the homestay period. The communities gain potential solutions to problems/opportunities, and they may have contributed to the development of the solutions. Furthermore, the students leave a two-week program with many of the attributes that are desired from accreditation bodies and universities.

However, the three principles of service-learning from Sigmon (1979) are not explicitly reflected by EWB Design Summits. Those being served have some control of the service provided (Principle 1) and they are better able to serve and be served by their own actions (2). Unfortunately, this is not through the design work, but rather the transactional relationship in the EWB pay for accommodation during the homestay period. That is generally the extent of the benefits to the communities. The students developing the prototypes have the intent of providing something useful to the communities; but that is not the aim of the Summit. There is no expectation of follow-up work or taking a prototype to a commercially viable product as there are dozens of Summits run each year, and therefore 100s of prototypes developed each year.

Doing otherwise would put EWB into a position of potential conflict of interest. Teaching students to go through the entire human-centred design approach needs to accept that not all prototypes will be successful. Failure has to be accepted as a possibility. Therefore, no emphasis is placed on the development of a prototype. The communities do not have any expectation. The EWB Design Summit is therefore an example of service-learning that does not adhere to the principles of Sigmon (1979), but still provides a major benefit to all parties.

3.1.1. Project Everest Ventures Treks

Project Everest Ventures (PEV) is an Australian-based organisation. Like the EWB Design Summits, PEV take university students and deploy them on 'Treks' to resource-constrained communities including Malawi, East Timor, Fiji and India (Nepal was the original destination, but the 2015 earthquakes closed that operation). Student numbers for each Trek range from 20 to 35. Like EWB Design Summits, the PEV

Treks run in the summer and winter breaks for Australian universities. However, where EWB Design Summits have a focus on training students in human-centred design, PEV Treks focus on the development of sustainable products and business. In this was PEV see themselves as an incubator for development solutions.

Prior to a Trek, students (known as 'trekkers') are taught about human-centred design, and cultural awareness, and other skills required to operate a small start-up in a resource-constrained community. This training is conducted in Australia prior to the Trek. The teams (of approximately 10 trekkers) are formed based on the specific projects that they will work on during the Trek, and so there is time for teams to start building prior to getting into country.

The Treks themselves last for four-weeks. During that time, trekkers apply the knowledge of human-centred design, and the skills they have from university education to work on part of the design cycle. They might identify new problems/opportunities, develop solutions, establish required businesses (following a lean start-up model of Ries (2011)), and/or run them. In this way, a proposed solution may have various trekkers contributing for years to get to commercial sustainability. They may also be required to close non-viable businesses.

The PEV Treks address the principles of Sigmon (1979), but through the lens of capitalism and a macroscopic view. (1) *Those being served control the service provided* – the communities are getting a product that they want. The communities have been engaged with the consultation process since the beginning of problem identification. (2) *Those being served become better able to serve and be served by their own actions* – commercial viability includes consideration of local employment and local supply chains. The work PEV does theoretically provides an increase in market activity. (3) *Those who serve also are learners and have significant control over what is expected to be learned* – the students pre-select projects and countries for the Treks. They contribute to their group using their existing knowledge and as a group, they work on a business venture. Throughout all of this, the trekkers benefit from the experiences they have and, like the EWB Design Summits, develop many of the 'soft skill' attributes required of renaissance engineers (and non-engineers).

An argument against PEV is that they are not focused on a specific small-scale community, but rather a regional area. The opportunities may end up being focused, and therefore greater small-scale community engagement may occur, but that is not a predetermined aim. Furthermore, PEV aim to have sustainable businesses running in these countries. This sustainability includes financial sustainability. They are not a charity and not a not-for-profit entity. The origins of service-learning and international volunteering are based on a sense of charity. By PEV striving to establish social-good, but profitable business ventures, they go against the establishment (both in service-learning educational sectors and international development sectors). Nonetheless, they still provide mutual benefit to those who serve and those who are served.

3.1.2. Windaid institute

WindAid Institute operates exclusively in Peru. They accept university/college students and professionals from around the world to design, build, and install wind turbines throughout the year in one of 12 different placements (WindAid Institute). The volunteers need no specific technical experience, so during the four-week placements, the students learn while doing. On the assumption that there is a reflection period, then WindAid Institute following the requirements of experiential learning (Felicia 2011).

WindAid Institute work in partnership with local communities, other NGOs and charities to identify suitable recipients of the wind turbines produced. Similar to PEV, there is a macroscopic community engagement, rather than ongoing end-user community-specific engagement. This point in isolation would indicate that WindAid Institute may not address Principles 1 and 2 from Sigmon (1979). However, as the wind turbines provide communities with access to electricity, they have empowered them to serve themselves more. It can be argued that WindAid Institute address the three principles of service-learning, but like EWB and PEV, the end-user communities are not explicitly taught anything.

Unlike PEV, WindAid Institution relies on the financial contributions of volunteers to cover the costs of wind turbine manufacturing and installation. Its business model is therefore reliant on volunteers and hence the motivation of volunteers. The volunteers do not need any specific skills prior to arrival and the volunteers need no work-related motivation to gain knowledge about wind turbine design, build or installation. It can be assumed that the volunteers motivation includes wanting to help, wanting to travel, wanting to learn something new. In this case, there is a significant risk that WindAid Institute could fall into a category of voluntourism. If the motivation is to learn about wind turbines, that can be done in most home locations and online. If the motivation is to help communities, then the money spent on flights, accommodation and registration fees could be donated directly to WindAid Institute to employ locals to do the work. If the motivation is to travel and have an authentic experience, then social-good tour companies exist to support that. It should be made clear that WindAid Institute do train and employ locals in all aspects of their work. They are not reliant on just the work of the volunteers. The authors's opinion is

that WindAid Institute does not fall within the category of voluntourism, but there is a risk it could shift in a negative direction. The perception of the volunteers also needs to be considered (something beyond the scope of the current work) to determine pre- and post-placement opinions with regards to neo-colonialism and the need for westerns to come in a save the day because those in resource-constrained communities do not know better.

3.1.3. Milwaukee school of engineering and global brigades

Milwaukee School of Engineering (MSOE) runs a global humanitarian outreach program for engineering, nursing and business students. To minimize logistical and administrative issues MSOE logically partnered with a third-party provider, the NGO Global Brigades. The MSOE program historically started for the nursing cohort, which corresponds to the initial focus of Global Brigades (when it was initially called Global Medical Relief). Nursing students travel to resource-constrained communities in South America to practice their skills. Specifically, 'students collect medical informatics data concerning the general health of the populations served by the Medical Brigade as well as information on primary care, disease management, and treatments' (Carlson-Oehlers, Jung, and Cohen 2017). In this way communities obtained improve medical support. That is, the first principle from Sigmon (1979) *those being served control the service(s) provided*. Additionally, there are aspects of the third principle '*those who serve also are learners and have significant control over what is expected to be learned*'. It is questioned if complex medical training could be ethically imparted to community members in such a short timeframe, hence the second principle could not, and arguably should not, be achieved. In light of the medical aspect of the program MSOE run, like the other case studies provided, it does not necessarily follow all the principles from Sigmon (1979), but provides mutual benefit to all parties.

Carlson-Oehlers, Jung, and Cohen (2017) goes on to detail the 2017 program whereby engineering students contributed to the construction of facilities in seven separate households in Nicaragua. Work included 'digging holes for the septic tanks, mixing concrete for the floors, laying the cinderblock walls, etc'. These roles require little to no skills or pre-training. Additionally, an engineer is not required to dig a hole or mix concrete in their future industry employment.

There are possible benefits in engineers understanding the difficulty of these types of manual labour, but a student does not need to travel 5000km to dig a hole. Furthermore, if that training was required in graduate engineers (renaissance or not), then the students would have already experienced hole digging at their respective universities. A consequence is that local community members who may depend on manual labour jobs have these jobs taken away. The students gain (non-essential) experiences at the expense of local employment.

There are alternatives that could be provided. The students could work on designing systems, such as the septics and buildings. They could project manage local staff. They could also train community members on those aspects of the work to ensure that the second principle of service-learning is achieved and *those being served are better able to serve and be served by their own actions*. Unfortunately, a building site needs just one project manager. It is understandable that MSOE have expanded a good program to include an engineering cohort, but finding the balance of high student numbers applying the relevant knowledge on projects in foreign countries with helping build capacity in the communities is complex. If it was an easy task, then voluntourism would not exist in its current and detrimental state.

3.1.4. Detroit

Dukhan, Schumack, and Daniels (2008) discuss service-learning on students' attitudes and identity for a service-learning program at the University of Detroit Mercy (UDM). The paper presents surveyed results of student attitudes, supporting previous findings of the benefits service-learning provides. However, unlike the previous case studies in the current paper, where students went overseas to help communities, while also learning to be better engineers and global citizens; the team at University of Detroit Mercy took students from a heat transfer course and had them use curriculum-specific topics to support a local community partner, the Warm Training Center.

The Warm Training Center has an existing training program to teach community members about resource-efficient housing. Support given to the Warm Training Center can therefore provide indirect benefits to community empowerment, thus meeting the first and second principles of service-learning.

The students were used to help with building assessments and installations. These would be tasks that an engineer may do in their job. Subsequently, no employment opportunities were taken away, and the students learned course-specific knowledge. However, in a core course, what students expect to be learned is limited. Therefore, the third principle of service-learning (*those who serve also are learners and have significant control over what is expected to be learned*) is not necessarily achieved.

The program presented by Dukhan is elegant in how easy it appears to meet the principles of service-learning while having clear benefits to UDM (through improved reputation), student knowledge, and student retention. It doesn't fit the mainstream perceptions of 'global' or

'humanitarian' work, but still produces the positive outcomes of many other programs. Furthermore, students are not expected to pay for international flights, registration or accommodation. They do not get to be tourists, but at what stage in their education do they need to be a tourist? Overall, this follow the work detailed by VanderSteen, Hall, and Baillie (2010) of doing 'humanitarian engineering' placements in students' own local communities.

4. Discussion of case studies

The case studies presented show different types of service-learning programs. Indirectly, they all follow the principles of service-learning detailed by Sigmon (1979); however, in most cases, not all principles are directly followed. EWB Design Summits provide community empowerment by paying for accommodation, thus addressing principles 1 and 2 indirectly. PEV Treks rely on commercial viability of products, thus directly addressing principles 1 and 2. WindAid Institute provide electricity to a community as the means of addressing principle 2, but the business model borders on voluntourism. MSOE provides improved health to communities, thus directly addressing principle 2; however, their engineering program is arguably voluntourism. Even UDM only indirectly address the principles by working through the Warm Training Centre, and may have limited release of control to what students expect to learn. A summary of these relationships to Sigmon's Principles is given in Table 1. All of these case studies show that rigidly following the principles may limit opportunities for quality education and community benefit. The intent of the current paper was to develop a framework for determining voluntourism. The three principles from Sigmon (1979) exist as follows:

(4) those being served control the service(s) provided;
(5) those being served become better able to serve and be served by their own actions;
(6) those who serve also are learners and have significant control over what is expected to be learned.

These provide a guide as to program motivation. In addition to these Dukhan, Schumack, and Daniels (2008) detail the major elements to their service-learning approach. These elements are:

(7) identifying and lecturing on technical content related to one or more course outcomes;
(8) selection and lecturing on a community-service activity with clear and strong linkage to the technical content;
(9) performing the community-service activity;
(10) performing the engineering analysis;
(11) reflection on the service-learning experience;
(12) assessment of the impact on students' attitudes and awareness.

To improve each of the above case studies further analysis is needed to ascertain the expectations and needs of the respective communities and students. While this is a large endeavor and perhaps beyond the scope of the project organisers it is imperative to ensure that volunteerism is avoided, Sigmon's principles are present and experiential-learning and/or service-learning are present to create the 21st century engineer. By combing the principles of Sigmon (1979) and the elements of Dukhan, Schumack, and Daniels (2008) a richer experience of mutual benefit for communities, students and the organisations can be achieved.

A deeper analysis is needed to establish a greater understanding of the positive and negative attributes of each of the case studies and why this is the case. The authors proposes that each case study adopts a rigorous participant observation methodology where the researcher is immersed in each of the case studies from the inception of the program to the end of the program and the subsequent evaluation. This includes obtaining feedback from community members from inception to project completion. Evaluation of programs should reflect the principles of Sigmon (1979) and the elements of Dukhan, Schumack, and Daniels (2008). It is suggested by the authors that successful monitoring and evaluating of the program is sufficiently complex to require expertise beyond undergraduate students.

5. Conclusion

An option to support universities in their task to develop engineers with attributes associated with being 21st century engineers and global citizens is in-country service-learning placements. In many cases the placements successfully address attributes that are difficult to develop in a lecture theatre only. However, with a shift in focus from communities that are served, to students on placement (as can occur for formalised learning-objective-centric teaching), the service-learning placement can become a neo-colonialist case of voluntourism. The well-intentioned staff and students disempower communities by taking away employment options and develop a level of charity addiction.

To avoid this, it has been shown that consideration of the three principles of service-learning are essential, but rigidly adhering to them is not. Rather, designing programs to constructively build on technical content taught in other courses, working with community benefit in mind, appreciating the long-term impacts of any outcomes, and fostering reflection of experience

Table 1. Summary of the case studies against Sigmon's principles.

Sigmon's Principles	Those being served control the service(s) provided	Those being served become better able to serve and be served by their actions	Those who serve also are learners and have significant control over what is expected to be learned.
EWB	There is slight control over the service being provided as the students are immersed into the community to see problems and opportunities, but the community does not have explicit control over which solution or prototype is developed.	The community may learn how to work through solutions through interactions with the students, but this is not the aim.	Learn human-centred design and identify projects to work on.
Project Everest Ventures	The region (not community) is obtaining a product they want as they have been engaged and consulted.	This program considers local employment and supply chains.	Students are able to pre-select the projects they wish to work on using their existing knowledge, or gain new knowledge not necessarily aligned to their field of study.
WindAid Institute	Not addressed beyond acceptance of products (wind turbines).	Installation of wind turbines provides communities with access to electricity and thus empowers them.	There is a choice of working on different aspects of the process (eg installation).
Milwaukee School of Engineering	The community indirectly controls the service through determining the improvement of medical services	Not addressed	Reinforcement of existing knowledge, but new learning is limited.
University of Detroit Mercy	Minor and indirect control	Only via the pre-existing structure of the program.	Reinforcement of existing knowledge, but new learning is limited.

is essential. In so doing, the students, universities, and communities can all benefit, such that 21st century 'renaissance' engineers are produced, and the long-term quality of life of communities being support is raised.

Disclosure statement

No potential conflict of interest was reported by the authors.

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