Primed Civil Engineers Into Human-Centered Designing (and Its Unexpected Consequences)

Nathalie Al Kakoun, Swansea University

Nathalie Al Kakoun holds a BEng in Civil Engineering (Hons) and is now pursuing a multidisciplinary PhD, crossing engineering with psychology, at Swansea University. Nathalie is currently researching and designing interventions that characterise empathy and social consciousness in engineers and civil engineering design processes. She is also currently researching engineering mindsets, attempting to understand (and further align) the compatibility of engineering mindsets to engineers’ engagement with public-welfare related, human-centred designing frameworks.

Dr. Frederic Boy, Swansea University

Frederic Boy is an Associate Professor in Digital Analytics and Cognitive Neuroscience at Swansea University’s School of Management and an honorary Senior Lecturer in Engineering at University College, London. Previously, he did his PhD in Grenoble University and trained in Cardiff University, where he held a Wellcome Trust VIP fellowship. His research interests include brain science, cognitive psychology, artificial intelligence and biomedical engineering. He is working on a range of multidisciplinary projects at the intersection of neuroscience and engineering, digital humanities and, more recently economics, with a new focus on the interplay between Artificial Intelligence and Mental Health.

Dr. Catherine Groves

A Chartered Occupational Psychologist and Senior Fellow of the Higher Education Academy, Catherine draws on over 20 years’ operational management experience, to support her academic work. She remains involved in supporting and advising on the work of a number of social enterprises and charities locally. Her main areas of interest and research are in action learning, critical management, social enterprise and all things psychological. As an experienced coach, Catherine is particularly active in the area of leadership and team development, making innovative use of virtual reality technology and critical thinking to develop and enhance leadership competency in M level students. She is also a highly experienced psychometrician.

Patricia Xavier, Swansea University

Patricia is a water engineer with a background in both the private and public water sector. She has expertise in the design of flood alleviation schemes and wastewater networks. Patricia leads Academic Programme Enhancement and Development for the College of Engineering. With her background in industry, she is keenly aware that the sector-wide academisation and de-contextualisation of engineering education is leading to an engineering sector that struggles to relate theory to practice.

Her main area of research is into the social impact of engineers and engineering – critiquing how the methodologies adopted by engineers can sometimes run counter to the needs of communities they serve and reinforce structures of power that maintain inequality. Civil Engineering in particular is inextricably linked up with societal change, and responsible engineering is about understanding wider environmental and social impacts of design and construction. Patricia teaches creative design modules that give students tools and techniques (Human-centered design, VR collaborative design tools) to find their own brand of creativity, while prompting students to consider how their individual privilege and biases impact on their design decisions.

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Abstract

There are many ongoing calls for the integration of public welfare concerns into engineering curricula, for example promoting social consciousness, human-centred design, and other socially-related frameworks. However, some engineering students still seem to devalue or resist these initiatives. This paper explores a new methodology to facilitate such integrations, with the intention of bypassing the possible resistance to considering non-technical, socially-orientated aspects, by exploiting a psychology-informed approach of priming.

As priming holds the potential of inducing empathy (a prerequisite to human-centred designing practices, and a precondition to consciousness), and bypassing ‘disruptive transitional behaviour’, we test to see if we can prime civil engineers into human-centred designing.

Students’ levels of self- and social-awareness and consciousness (which are also factors contributing to engineering professional formation), were recorded before and after their engagement with our version of a Human-Centred Design Task. The effect of priming on these indicators was also captured.

No significance in the before versus after results was found, and results showed no significant impact of the priming on the Self-Awareness Indicators.

However, there were unexpected results of students’ levels of Social-Awareness Indicators. Students’ levels of Social Consciousness were shown to have significantly decreased (rather than increased) due to the priming. The results led to further expanding the literature review to seek a possible explanation.

We discuss possible reasons behind these results, linking their decrease due to the priming, to the self-enhancing, agentic personal engineering values. These values appear to have a contribution towards decision making (and thus, problem solving), and an influence on the students’/designers’ engagement with empathy (which is a prerequisite to human-centred designing). This sheds light on the need to expand the research on the topic of engineering personal values, and their possible influence on human-centred design, and other socially-related design processes and factors.

Keywords: Engineering Education, Civil Engineering Design, Human-Centred Designing, Priming, Empathy, Social Consciousness, Personal Values, Engineering Values

Introduction

Many have discussed the technocentric engineering curricula [1] – [5], that tend to marginalise [3] and devalue [6],[7], the less technical and more ‘socially-involved’ aspects of engineering, and have thus stood with Cech’s [2] call for the integration of public welfare concern and social consciousness in engineering curricula.

have also risen. This is reflected in changes to requirements of accreditation [19] and professional formation development [20].

Giacomin [16] citing Von Hippel [21], discusses the economic benefits of human-centred designing, however, Niles et al. [22], [23], have found that engineering students seem to struggle with and resist social context and engagement with public welfare concerns and social consciousness in engineering— which are factors relevant to their engagement with human-centred designing.

This paper stands with these ongoing calls for the engagement and integration of such notions in a civil engineering curriculum, and so we propose a psychology-informed approach. This is to facilitate these integrations, but with the intention of bypassing the possible resistance – by priming.

**Human-Centred Designing, Empathy, and Social- and Self-Awareness**

Giacomin [16] describes how there seems to exist three distinct “major design paradigms”: *Technology Driven Design, Human Centred Design, and Environmentally Sustainable Design* (p.607), and how they differ by core intention. Human Centred Design, he [16] explains, is “based on the use of techniques which communicate, interact, empathize and stimulate the people involved, obtaining an understanding of their needs, desires and experiences which often transcends that which the people themselves actually realized.” (p.610). He further elaborates by “Human centred design is thus distinct from many traditional design practices because the natural focus of the questions, insights and activities lies with the people for whom the product, system or service is intended, rather than in the designer’s personal creative process or within the material and technological substrates of the artefact. Practised in its most basic form, human centred design leads to products, systems and services which are physically, perceptually, cognitively and emotionally intuitive.” (p.610)

More definitions for human-centred design include: “Human-centred design is a creative exploration of human needs, knowledge and experience which aims to extend human capabilities and improve quality of life” [18, p.9], and that it is “all about putting the human user at the heart of a product, system, or process. Human -centred designers use knowledge of human capabilities and limitation across a variety of methods, combining biomechanics, psychology and engineering, to produce a solution which is safe, efficient, and satisfying to use” [17, p.2-3; citing HCDI Brunel University].

Based on contemporary research in the field by others, Zhang and Dong [17] summarise the features of Human-Centred Designing (HCD) as:

- The central place of human beings;
- Understanding people holistically;
- Multi-disciplinary collaboration;
- Involving users throughout the design process;
- Making products or services useful, usable, and desirable; [17, p.3].

Zhang and Dong [17] propose a *conceptual model* of human-centred design that intersects Maslow’s hierarchy of needs [24] and Küthe’s model of “design and society” [17, p. 2] citing
revealing “a tendency that design evolution responds to the hierarchy of human needs” and that “nowadays design tends to care for more levels of human needs” [17, p.1].

All above definitions emphasise the weight of empathy in human-centred designing, and how such designs’ intentions are directed towards properly understanding, and positively impacting the end-users’, human quality of life.

Other than the positive impact on the human quality of life, and better usability of design/product produced, human-centred designing also seems to have economic benefits. Observed evidence show that such designing strategies enhance commercial success as “70% to 80% of new product development that fails does so not for lack of advanced technology but because of a failure to understand users’ needs” [21, p.28] – as cited in [16, p.615].

As already mentioned, human-centred designing has human needs set at the core of the design/design process [26], [27], and thus has its value rooted human needs and intentional positive impact on their quality of life. It is characterised by empathy [16], [10], [18], [28], in attempt to properly and deeply understand human needs, and tailor the design around the particular humans involved in the project in progress, and thus to provide more efficient, effective products and solutions.

Empathy, however, cannot be forced (according to Stein [29]), and Davis [30] indicates that the act of empathising cannot be taught.

Empathy is known to have ties with Self Consciousness and Social Consciousness. “Empathy is the precondition (the condition of possibility) of the science of consciousness” as Thompson [31] explains it. Indeed, Bekoff [32, p.26] argues that “Discussions of empathy necessarily include consideration of the notions of self-awareness (also referred to as self-recognition and self-consciousness)”, and Haley et al [33] found positive, significant associations between self-awareness and empathy. Davis [30] agrees that with the promotion of self-awareness, empathy is developed.

Additionally, Segal [34] explains how empathy and social consciousness are linked under the ensemble of Social Empathy. She explains (with reference to Freire [35]) how social action is characterised by the development of consciousness – which is the “combination of the self/other-awareness and the perspective-taking components of empathy” [34, p.271]. Further, she elaborates on how Social Empathy embraces social responsibility and promotes social justice and well-being. Segal [34] explains that via Social Empathy, people are better able to “deeply understand” peoples’ situations and needs, and therefore be better equipped to deal with these situations. Although Segal [34] concerned the activities of social workers, it is worth considering whether and how the framework could be extended to understanding how social empathy relates to the social impact of engineering design.

In addition to the above ties addressed, Chlopan et al. [36] (citing Mehrabian [37]), stated that “highly empathic individuals tend to show a great amount of social concern and tend to screen irrelevant environmental information less” (p.648). This further highlights the positive association between empathy and social concern, and social consciousness.

Moreover, Joslyn & Hynes [20] discuss how Self-Awareness, Social-Awareness, and engagement with human-centred designing, are associated with professional engineering
formation in undergraduate students. They explain how Self Consciousness is “one’s disposition to direct her/his attention towards her/himself; the existence of this self-directed attention produces a state of self-awareness” [20, p.2] (citing Fenigstein et al. [38]). This state of Self-Awareness “represents the extent to which one has identified and can articulate the personal values, professional values, and assumptions regarding professional roles and responsibilities that inform her/his professional identity” [20, p.2] (citing Natsoul [39]), which eventually maps onto professional formation.

Social-Awareness, on the other hand, is defined as “a state of focused attention on considerations of public welfare in one’s day to day life and it represents the extent to which one considers matters of public welfare” [20, p.2] (citing [2] and [40]), and that the “ability to consider matters of public welfare is highly influenced by the professional formation process” [20]. Moreover, social consciousness was indeed one of the four public welfare beliefs that were examined by Cech in her study of ‘Culture of (Dis)engagement in Engineering Education’ [2].

Joslyn and Hynes [20] point out that design courses offer the opportunity to “integrate the development of engineering students’ self and social-awareness”. This can be facilitated by engagement with user-centred, human-centred, empathic and compassionate designing, emphasising the importance of engaging with such design frameworks with the aim of supporting professional formation. Walther et al. [41] also agreeingly argue the emphasis of empathy on the development of engineering formation.

Joslyn & Hynes designed an instrument to capture and measure levels of self-awareness and social-awareness indicators (the Self-awareness and Social-awareness Assessment) (SSA) of engineering students, before and after their engagement with a human-centred design project [20]. This instrument is adopted in the present study and is further discussed in the methodology.

The ‘setback’ – Resistance and Devaluation

Niles et al. [23] investigated how engineering students respond to public welfare engagement and working with public welfare related issues. They found that although students seem to get excited for working on public-welfare-related work, they also seemed to resist it. Niles et al. found that the challenges that often lead to students’ resistance to public welfare issues are the following: “(a) defining and defending students’ identities as engineers; (b) justifying the value of nontechnical work and relevance to engineering; (c) redefining engineering expertise and integrating community knowledge into projects; and (d) addressing ambiguous questions and ethics” [23, p.6].

Niles et al. [23, p.6] explain the struggles engineering students experience when public welfare related assignments are “foregrounded”. They [23] explain how that disrupts the “technical/social dualism in engineering” which eventually leads to the complications of the students’ understanding of “what it means to be an engineer, what engineers do, and what constitutes engineering knowledge and expertise”. Niles et al. [23, p.6] further explain how this “created difficulties for students as they contended with conflicting conceptions of engineering knowledge and practice”.

Moreover, the findings of Niles et al. [23], along with others that describe how engineering paradigms are heavily rooted in, prioritising technocentrism [1] – [5], and consumerism and
financial profit [42] paint the picture of any other engineering characteristics that sit outside of that outline (like empathic, human-centred, humanitarian, and social aspects of engineering) are often devalued or belittled [6], [7], and/or resisted [22], [23].

Our Study: Can we bypass resistance and devaluation?

This paper stands with the notion that suddenly, obligatorily, and extrinsically forcing engineering students (as one would in a typical top-down education dynamic) into something of little value and already shown to be resisted, may cause further resistance or even possible backlash from the students. This is especially particular when their engineering schedules are already overloaded with ‘more important’ – usually more technical – assignments.

Therefore, the intention was to trigger subtle, internally-induced change towards more empathic, socially conscious, and ‘human-centred-designing-compatible’ mindsets in design, without having to go through the possible resistance and/or backlash from students.

As studies show that Priming can facilitate such subtle, subconscious, internal change, and that empathy can be induced by priming, we set out an intervention to check if we can ‘Prime Civil Engineers into Human-Centred Designing’.

About Priming

The priming effect is an unconscious prompt that occurs as a result of a subtle, contextual cue (a prime) that activates an existing semantic association in the mind of the receiver. This can have an effect on behaviour [43], [44], perceptions [45], performance on a cognitive task [46] and attitudes and values [47].

Priming has been a known persuasive technique used widely in Politics [48], Marketing and Advertising [49] and in the educational process of autistic children [50], as it is also shown to surpass ‘disruptive transition behaviour’ [51].

Priming has also been shown to induce emotions of happiness and anger [52]. It affects empathy [53] in both a prosocial behaviour context [53] and in a ‘feel others’ pain’ context [54] and is shown to influence empathic responding [55].

In a classic example from 1957, James Vicary showed that people watching a movie in a theatre hall consumed more popcorn and drank more Coca Cola when they were visually primed to do so. Although some accused this to be a hoax, Karremans et al. [56] conducted a similar study, and found aligning results.

The semantic association from priming occurs as follows: When an individual has to give a fast response on Topic A, whilst subject to the unconscious influence of Topic B (through exposure to a prime associated with Topic B), the schema (set of memories, understandings, and experiences) of both Topic A (conscious) and B (unconscious) are thus activated. This process is automatic, unconscious, and passive, and allows the experiences and mindset associated with Topic B to influence the solution produced consciously for Topic A (see [57] – [59]; and [43] for more information).

Any form of sensory trigger that has the ability to trigger a semantic schema has potential to be a prime, though olfactory [60], auditory [61], and/or visual [62] are most commonly adopted. When the prime is above the conscious detection threshold it is termed supraliminal and when below this threshold it is termed subliminal. Subliminal priming is usually
characterised by the flashing of a prime, quick enough to influence, but to also remain undetected by the human consciousness [63]; whilst in supraliminal priming, exposure to primes can be longer in duration [63], but its’ intention still has to remain undetected, for the effect to be feasible [63]. Supraliminal visual priming is considered to make a ‘longer-lasting’ effect than subliminal [64].

Priming has been used to: improve speech delivery and leadership skills in women primed with pictures of powerful women [65]; and trigger other traits (e.g. creativity triggered by images of the Apple logo, or ‘honesty’ triggered by the Disney logo [66]).

Based on the above, it appears that priming could have a role to play in engineering design processes, in cases where a particular mindset or set of values has relevance to a design task. This is particularly true in the case of mindset and values that are not already being strongly associated with engineering schema within the mind of the student (or even often being resisted and/or devalued). For example, in the case of inducing a mindset compatible with design for public welfare and engagement of social consciousness, the use of primes could possibly facilitate empathy. In addition to facilitating/inducing empathy in engineering students towards the people they are instructed to design for, we think that the priming pictures could hold the potential of aiding the students/designers into visualising and thus better understanding the situations they are to design for. The primes, we think, can also act as ‘reminders’ of the impact engineers have on quality of life through design.

Targeted behaviours have been shown to increase over time as a result of using primes [50]. As a result, repeated application of priming (and even on a larger scale – not just restricted to a classroom intervention/workshop), could act as a ‘human-centred’ mindset and value reinforcer in engineering settings, over time.

**Research Questions**

This study seeks to investigate the following research questions:

**RQ 1.** What effect does engaging with the Human-Centred Designing Task have on the Self-Awareness and Social-Awareness Indicators (SSA Indicators) of the Primed (P3) and NonPrimed (P1) groups?

**RQ2.** What effect does the priming have on the Self-Awareness and Social-Awareness Indicators (SSA Indicators) before engaging with the Human-Centred Designing Task?

**RQ3.** What effect does the priming have on the Self-Awareness and Social-Awareness Indicators (SSA Indicators) after engaging with the Human-Centred Designing Task?

**Methodology**

**Integrating Human-Centred Designing, Max-Neef’s Matrix of Basic Human Needs, and Priming**

Campbell and Wilson [67] proposed that “When one has:

1) a specific location or people in mind;
2) involved those people in the design and decision-making process; and
3) together reached a consensus on solutions that are in the people's best interest; one is much closer to the economic, environmental, global and societal issues and one can better understand their importance” [67, p.4].

Achieving human-centred designing activities in the engineering classroom comes with challenges. To be authentic, human-centred designing requires students to actively involve with end-users, and it is not straightforward to provide this to all students in all contexts. There are practical and ethical considerations in asking students to work directly with individuals and communities.

Another approach, potentially as a preparatory exercise for participatory human-centred designing is to take an aspect – human needs, and familiarise students with the concepts associated.

Our case study involved the structural development and improvement of the residents’ quality of life of one of two adjacent, yet very contrasting in structural development, districts in Beirut, Lebanon – Hamra and Shatila. The two districts are only 4.1 miles apart, yet Hamra is a prosperous area with adequate infrastructure, and Shatila is refugee camp, initially designed to accommodate 3000 people, but is now accommodating 40000 [68].

Students were unable to collect data first hand on the residents’ quality of life and human needs, nor could they interact with the people. Therefore, we provided reports on the quality of life of the residents of both districts (with numerical data indicating the prevalence of health conditions in either region, levels of education and employment statistics etc.).

We also provided them with Max-Neef’s Matrix of Basic Human Needs [69]. The matrix incorporates and lists all basic human needs that typically have to be met in order to live a satisfactory life. It was chosen as we preferred not to treat human needs in a hierarchical manner, but rather consider and involve notions related to them in a lateral, more inclusive manner. This, we argue, nudges design towards simultaneously considering all needs, from sustenance (typically considered lower-order and pre-requisite to other needs) to social needs (typically considered higher-order, and therefore not as urgent to meet). This is standing with the notion that metaphysical human needs are just as important as basic physical needs when considering human-centred design in engineering settings.

Maps and plans of either district (along with residential listings and form of occupation – domestic or business) were also given to the students, this was to give them an insight on the ‘urbanisation’ of either district and of the road networks, to facilitate the designers’ understanding of the environmental and cultural scenario/status they are to ‘deal with’.

This Human-Centred Designing Task composed of two sections: The first was for the students to compare the structural development of either district, and reflect and make the connection of how many of the human needs (of the Matrix of Human Needs of Satisfiers) are already considered in each plan, and therefore see how that is reflected in the quality-of-life reports of the residents of either district.

The second section was to design a Human-Centred Design for the people of Shatila, with the purpose and intention of positively impacting their quality of life. They were encouraged to include as many of the human needs (of the Matrix of Basic Human Needs and Satisfiers) that the people of Shatila ought to have currently missing. The students were also encouraged
to look for the ‘root’ of the problems and solve for that instead of providing ‘plaster’/temporary solutions for Shatila’s current situation. ‘Creative solutions’ were also encouraged by prompting students to try to solve multiple issues per solution or design. They were continuously encouraged to ‘put themselves in the shoes’ of those living in Shatila that they are designing for, in attempt to help them understand what the ‘true’ problems are and what they, as people, would need, to therefore produce more effective (and empathic) human-centred designs.

Primes used in this paper were visual: supraliminal, pictorial cues were used to intentionally trigger certain schemas and internal responses (specifically, empathy and ‘understanding’) in the students, during their Human-Centred Designing Assignment. The reason behind choosing supraliminal pictorial primes was because it was the most convenient form of sensory priming to be set in an in-class intervention, and is shown to be longer lasting in effect [64].

The primed cohort (P3) was primed with A5 (148 × 210 millimetres) pictures of the residents of Shatila. The pictures were hung at the students’ eyelevel whilst seated, on their surrounding walls (see Figure 1). The pictures were of the residents carrying day-to-day activities, clearly presenting their disadvantaged standards of living. They were pictures of children playing in unfit places like dumpsters, and people walking down a street with waste lying on either sides, and improper electrical cables instalment, dangling just above their heads. They were meant to show the unsafe, unhealthy status of living, and to thus induce empathy (cognitively – in further understanding their mode of living and needs, and emotionally – in further aiding the compassionate designing) in the students exposed to them.

The NonPrimed group (P1) acted as our control group (as they were seated reasonably far away from the priming pictures – see Figure 1), and the Middle group (P2) results will be disregarded in the analyses, as students in the Middle group (P2) may or may not have been influenced by the priming (See Figure 1).

Had any of the students questioned the presence of the pictures, the intention was to respond with “for aesthetic purposes”, and that the reason they were not scattered across the whole lecture hall, would simply be “due to shortage of time” – but there were no questions regarding the presence of the pictures.

The students primed were not briefed or informed of the priming, for the feasibility and technicalities of such experiments, as for priming experiment to work, primes have to remain undetected [63].

This priming intervention was approved by the College Ethics Committee before taking place, and students were informed that none of their responses would affect their module grade in any way, and that taking part in this intervention was voluntary.

All students (of the Primed (P3), NonPrimed (P1), and Middle (P2) cohorts) were requested to fill in a Self-awareness and Social-awareness Assessment (SSA) [20], directly before and directly after, their provision of a solution and a design for the people of Shatila (Human-Centred Designing Task) (see Figure 2).

Participants

Our case study involved third year civil engineering students at a university in Wales.
127 third year civil engineering students were involved in this study (17% of them were female, and 49% were international students).

The students were pre-set (prior to this intervention) in groups of 5 or 6, based on their academic averages – groups of High, Medium, and Low academic averages. These groups were evenly spread across a 22m x 10m lecture hall, making sure that each ‘zone’ (of the P1, P2, P3) of the hall had an identical number of High, Medium, and Low grade-point average groups (See Figure 1). The diversity of each student group was not controlled.

![Figure 1 - Room and Group Layout (Ovals Represent Student Group Tables)](image)

**Procedure**

Prior to working on the Human-Centred Designing Task, a class discussion was held – discussing the topics of Social Impact, Social-Awareness and Social Responsibility in the Civil Engineering Paradigm.

Students discussed how, and to what extent, they think Civil Engineers and Engineering Designs impact society and peoples’ quality of lives (for example health, happiness, and satisfaction), and what their responsibilities are towards bettering them. They were also encouraged to think about and analyse their privileged encounters with such civil engineering designs, and imagine how different their lives would have been, had they not been exposed to such designs and solutions. This is a necessary stage of triggering the initial stage of empathy (relating to those who have not been exposed to such engineering solutions, and understanding how such encounters (or the lack thereof) affect their lives and needs), setting the goal and platform for the empathy priming to initiate its influence.

It is also important to note that the students were also first presented with the concept of ‘designing for the people’ then (during the intervention). They were introduced to the notions of Social Impact, and properly defining human needs (by properly understanding, with the use of empathy) to therefore effectively and successfully design solutions for the purpose of bettering peoples’ quality of lives.
Just before the Human-Centred Designing Task, sheets and the relevant documents were distributed, all students (of P1, P2, and P3 groups) were requested to fill SSA Instrument [20] questionnaires. This was to collect data on Self- and Social-Awareness and Consciousness of Students prior to their engagement with the Human-Centred Designing Task. The students were also requested the fill in another (identical) SSA Instrument directly after their provision of a solution and a design (after their engagement with the Human-Centred Designing Task) (see Figure 2). Self- and Social-Awareness/Consciousness have been shown to have associations with empathy (see Introduction), which is a requisite facet to human-centred designing.

The Human-Centred Designing intervention/lecture lasted for a total of 4 continuous hours (see Figure 2).

**Figure 2 – Lecture Procedure Layout**

Self-awareness and Social-awareness Assessment – SSA Instrument

The *Self-awareness and Social-awareness Assessment* (SSA) was designed by Joslyn & Hynes [20] and is based on Scheier and Carver’s [70] Revised *Self-Consciousness Scale*, for measuring the *Self – Awareness Indicators*, and Cech’s [2] *Measures of (Dis)Engagement*, for measuring the *Social – Awareness Indicators* of students, before and after engaging in a human-centred designing project [20].

The SSA Instrument is composed of two parts – the first measures the *Self-Awareness Indicators*, and the second measures the *Social-Awareness Indicators*.

The first section is composed of 22 items, which measure three subscales of Self-awareness (Public Self Consciousness, Private Self Consciousness, and Social Anxiety). For each item, respondents are requested to rate how much the person described is like them. Responses ranged from 0 (*Not like me at all*) to 3 (*Very much like me*). Examples of these items include:
“I know the way my mind works when I work through a problem”, “I’m constantly thinking about my reasons of doing things”, and “I feel nervous when I speak in front of a group”.

The second section, that measures Social-Awareness Indicators as means of public welfare beliefs and social consciousness, is composed of three subsegments;

The first subsegment is composed of three items, and asks the respondents to rate their personal importance of multiple public welfare beliefs. Students are asked to respond to the question: “What, in your opinion, makes a successful engineering career?” by rating “Professional and ethical responsibilities”, “Understanding the consequences of technology”, and “Understanding how people use machines” according to their considered importance. Responses range from 1 (Very Unimportant) to 5 (Very Important).

The other two subsegments, composed of three items each, address and rate the respondents’ personal, and their engineering program’s importance of other public welfare beliefs, which are grouped as social consciousness. Students are asked to respond to the question: “Please indicate the personal importance to you of:” by rating “Improving society”, “Promoting racial understanding” and “Helping others in need” according to their personal importance. The other question asks students to “Please indicate the importance to your engineering program of:” by rating “Ethical and/or social issues”, “Policy implications of engineering”, and “Broad education in humanities and social sciences” according to their engineering program’s importance. Responses for this subsegment range 1 (Very Unimportant) (1) to 4 (Very Important).

Results

After disregarding the responses of the Middle (P2) group from the dataset, a total of 54 SSA Instrument responses were collected from the students before, and a total of 51 responses was collected after, the engagement with the Human-Centred Design (HCD) Task.

Due to the ordinal nature of the data collected using the SSA Instruments, significant differences across the groups were obtained by running a Nonparametric Mann Whitney Tests on SPSS. P values obtained from Mann Whitney tests on SPSS are all with a confidence interval of 95%, by default.

Mean values, Standard Deviations, as well as Mean Ranks (in Tables 3 and 4) have been provided.

Emboldened p-values indicate significance in difference; with (*) indicating p < .05 and (**) indicating p < .01 [see Result Tables in Appendix].

Results answer to, and are displayed in order of the research questions proposed earlier. All result tables can be viewed in the Appendix.

RQ 1. What effect does engaging with the Human-Centred Designing Task have on the Self-Awareness and Social-Awareness Indicators (SSA Indicators) of the Primed (P3) and NonPrimed (P1) groups?

Table 1 displays the SSA Instrument results for the Primed (P3) group only – before and after their engagement with the Human-Centred Designing Task. The displayed p-values indicate that there exists no significant differences across the before versus after results of the Primed
(P3) group, and thus engagement with the Human-Centred Designing Task showed no significant effect on the Self- and Social-Awareness Indicators of the Primed (P3) group students.

Table 2 displays the SSA Instrument results for the NonPrimed (P1) group only – before and after their engagement with the Human-Centred Designing Task. The displayed p-values indicate that there exists no significant differences across the before versus after results of the NonPrimed (P1) group, and thus engagement with the Human-Centred Designing Task showed no significant effect on the Self- and Social-Awareness Indicators of the NonPrimed (P1) group students.

RQ2. What effect does the priming have on the Self-Awareness and Social-Awareness Indicators (SSA Indicators) before engaging with the Human-Centred Designing Task?

Table 3 displays the SSA Instrument results for the Primed(P3) and NonPrimed (P1) groups, before engaging with the Human-Centred Designing task. The displayed p-values in Table 3 indicate that there exists no significant differences across the Primed (P3) and NonPrimed (P1) groups’ Self-Awareness Indicators, signifying that the priming showed no apparent effect on the Self-Awareness Indicators of the designers, before their engagement with the Human-Centred Designing Task.

However, the p-values displayed in Table 3, show that the difference between the two groups’ majority of Social-Awareness Indicators are significant. This indicates that the priming seems to show influence on (all but three) Social-Awareness Indicators, and Social Consciousness of the designers/students, before their engagement with the Human-Centred Designing Task. Observing the mean values of the flagged-significant Social-Awareness Indicators, the priming seems to decrease, rather than increase, these Indicators and Social Consciousness.

RQ3. What effect does the priming have on the Self-Awareness and Social-Awareness Indicators (SSA Indicators) after engaging with the Human-Centred Designing Task?

Table 4 displays the SSA Instrument results for the Primed(P3) and NonPrimed (P1) groups, after their engagement with the Human-Centred Designing task.

Similar to Table 3, the displayed p-values in Table 4 indicate that there exists no significant differences across the Primed (P3) and NonPrimed (P1) groups’ Self-Awareness Indicators, signifying that the priming showed no apparent effect on the Self-Awareness Indicators of the designers, after their engagement with the Human-Centred Designing Task.

Also, the p-values displayed in Table 4, show that the difference between the two groups’ majority of Social-Awareness Indicators are significant. This indicates that the priming seems to show influence on (all but two) Social-Awareness Indicators, and Social Consciousness of the designers/students, after their engagement with the Human-Centred Designing Task. Observing the mean values of the flagged-significant Social-Awareness Indicators of Table 4, the priming seems to decrease, rather than increase, these Indicators and Social Consciousness.

Observing Table 3 and Table 4, it was interesting to note that the difference between the Primed (P3) and the NonPrimed (P1) groups, for the Social-Awareness Indicators: Understanding Consequences of Technology, Improving Society, and Helping Others in
Need, only became significant after the engagement with the Human-Centred Designing Task. On the other hand, the difference between the Primed (P3) and the NonPrimed (P1) groups for the Social-Awareness Indicators: Ethical and/or Social Issues and Broad Education in Humanities and Social Science, changed to no longer significant, after the engagement with the Human-Centred Designing Task.

Discussion
The results of Tables 3 and 4 reveal an unexpected, decreasing effect of the priming, on the social consciousness levels (and thus by literature extension, empathy) of civil engineering students during the proposed Human-Centred Design Task. We sought explanation on the decrease in empathy due to priming, and found the following studies:

- Myyrya et al. [71] and Price [72] have shown that measured empathy records correlated negatively with those with Self Enhancement values, and correlated positively, with those with Self Transcendent values. Additionally, Price [72] and Balliet et al. [73] predicted that highest levels of empathy are to be found positively correlated to Benevolence Values, and lowest levels of empathy are to be strongly and negatively correlated to Power and Achievement values.
- Price, [72, p.131] stated that “People who were highly motivated by the self-protecting, anxiety-avoidant, self enhancement values experienced the emotions of others to a lesser extent, and were less able to correctly identify a person’s emotional state”; hence, those motivated by Self-Enhancement have a harder time empathising with others.
- Moreover, Galinsky et al. [74] study the influence of priming ‘power’ on perspective taking (a form of empathy). Their results showed that “power was associated with a reduced tendency to comprehend how other people see, think, and feel” [74]; hence, those motivated by or have value for ‘power’, tend to display reduced empathy for others. An associating note here is that Power is a subset (basic) value of Self Enhancement (see Figure 3).

This reveals that Personal Values may have had an underlying influence on the results and students’ engagement with empathy, social consciousness results, and thus the human-centred designing process.

The Personal Value system addressed in [71] – [73] displayed above, is the Schwartz’s Personal Value system [75], [76].

Schwartz [75, p.3] describes values as what “we think of what is important to us in life” and further elucidates that “each of us holds numerous values (e.g., achievement, security, benevolence) with varying degrees of importance.”

His value system consists of basic values which all people hold, but in varying rank or order according to personal relevance, importance and priority. This “tradeoff amongst the relevant values” [75, p.12] within the value system of a person, is what classifies which category (named Higher Order Value) of the human value system this person resides in, and therefore how this person’s motivation and decision-making processes are driven.
All values and Higher Order Values of the Schwartz Personal value system map onto Schwartz et al.’s Circular motivational continuum [76, p.7], shown in Figure 3, for clearer representative indications of the Higher Order Values and their underlying basic values.

An important note to this system is, that Higher Order Values that are visually represented on opposing sides to each other of the Circular motivational continuum (see Figure 3) (like Self Transcendence and Self Enhancement, and similarly, Openness to Change and Conservation), are indicated to be adverse in nature, and that they cannot be simultaneously ranked highly in a single person’s personal value system. Thus, values that sit opposite to each other on the Circular motivational continuum (see Figure 3), are opposing in nature, and are mutually exclusive.

Schwartz [75, p.3-4] explain that values “refer to desirable goals that motivate action: People for whom social order, justice, and helpfulness are important values are motivated to pursue these goals”. Schwartz also adds that values “serve as standards or criteria: Values guide the selection or evaluation of actions, policies, people, and events. People decide what is good or bad, justified or illegitimate, worth doing or avoiding, based on possible consequences for their cherished values. But the impact of values in everyday decisions is rarely conscious. Values enter awareness when the actions or judgments one is considering have conflicting implications for different values one cherishes” [75, p.3-4].

Further, more expansion on the literature review was sought, to check if indeed, civil engineers have personal values rooted in Self Enhancement; we found:
According to Diekman et al. [77], “STEM careers are perceived as less likely than careers in other fields to fulfil communal goals (e.g., Working with or helping other people)” and indeed, found that “STEM careers, relative to other careers, were perceived to impede communal goals” and that “communal-goal endorsement negatively predicted interest in STEM careers, even when controlling for past experience and self-efficacy in science and mathematics”; pointing out the agentic (as opposed to the communal) value of STEM.

Ramsey [78] took on a study to test for the value systems of students and faculty staff members of a science department in a university, and found that all participants involved (students and faculty) “perceived agentic traits as more important for success in science than communal traits”.

To connect value systems together, Trapnell and Paulhus [79] found that communal values are more correlated to Self-Transcending and Conservation ones, and similarly, agentic values to mostly Self-Enhancing values, of the Schwartz’s Personal Value system. Their exact findings were as follows: “high loadings for achievement, power, hedonism, and stimulation: This factor clearly represents a superordinate agency dimension. The second rotated factor corresponds to a very broad communal dimension, combining vertical collectivist values such as conformity, tradition, and security, with horizontal collectivist values, such as universalism and benevolence.” [79, p.42]. This indeed reinforces the notion that engineers’ personal values may possibly be rooted in agency and self enhancement, and may have thus influenced the engagement with empathy, and Social-Awareness Indicators (public welfare beliefs and social consciousness results).

Personal values have been shown to influence decision making [80] (and by extension to decision making – problem solving [81]). Personal values have also been associated with moral judgement [82], [83], and also ethical decision making [84], which has associations to humanitarian engineering, according to Campbell & Wilson [67].

On the association of empathy and personal value systems, a study by Oriol et al. [85] found a “strong relationship between self-transcendent aspirations, gratitude, and cognitive and affective empathy”. They [85; citing 86] further elaborate with “self transcendent goals are intrinsic aspirations that are considered prosocial, and they imply connecting with others and going beyond selfish concerns” [85, p. 2; citing 86]. Their results also supported Kasser and Ryans’ [87] notion that “Self-transcendent aspirations as community involvement focus people’s interest not only on themselves, but also on others” [85, p.7; citing 87]. A reminding note here is that the Higher Order Value of ‘Self Transcendence’ sits opposing to that of ‘Self Enhancement’ in nature (and on the Circular motivational continuum) (see Figure 3).

In addition, as the class happened to be male dominant, a gender influence may have contributed to the results, as Cech states that females have “stronger social consciousness beliefs than men” [2 p.56]. Although males are considered to be more agentic than females (see [88] – [90] for a review), Ramsey [78], however, found that females are just as agentic as males in scientific domains.

Also, as the diversity of each student group was not controlled, the results could therefore have been affected by a cultural hostile ‘they solve their own problems’ kind of mindset [91], [92].
Finally, there is always the possibility of each of the following occurring, causing this reverse/opposite impact to arise: Schrobsdorff et al. [93, p.1], summarising others’ contemporary work in the field, state that “Many factors have been identified that can modulate, cancel or even reverse priming effects, e.g., the response stimulus interval, absence or saliency of the probe distractor, task instructions, age, sex, perceptual load, composition of trials, stimulus presentation time, stimulus onset asynchrony, and prime awareness.”.

Our priming intervention and our unexpected findings of declining social consciousness results (and thus by extension, empathy), have led us to question whether they could have possibly ‘unveiled’ underlying strong factors that show to have a possible contribution and/or influence on civil engineers’ decision making (and by extension, problem solving), and their engagement with empathy, (and now:) public welfare belief, and social consciousness, and other human-centred designing engagement factors.

The findings of this study therefore shed light on personal values of engineers (and the values of the engineering paradigm) and how they relate to empathic, human-centred design, aspects of public welfare concerns and beliefs (in particular social consciousness), and the possible resistance and/or devaluation that may occur (as clearly, public welfare, human-centred designing values sit opposite to agentic ones).

**Conclusion**

According to the literature from sectors outside engineering, priming seems to offer a method to engage empathy in engineering students (a necessary precursor for human-centred design). In this study, students were visually primed, and their levels of Self- and Social-Awareness was assessed before and after engaging with a proposed Human-Centred Designing Task.

The results indicated that priming has an effect, but counter-intuitively, it appears to be a negative, reversing effect to what was initially intended. Levels of Social Consciousness (and thus by literature extension, empathy) have decreased, rather than increased, due to the priming.

Expansion on literature to make sense of the results obtained, led us to understand that personal values may have influenced engineering students’ empathy engagement, indicated by the pre- and post-task Self-awareness and Social-awareness Assessment results. This led us to believe that values of engineers and the engineering paradigm may indeed have an influence on socially-related engineering factors of design.

More consideration of the role and influence of values could shed light on understanding the weight of personal values in engineering paradigms, and the significance of their contribution towards empathic, human-centred designing, aspects of public welfare concern (in particular social consciousness). In this interpretation, the primes could be said to be ‘unveiling’ the Self Enhancement value system of engineers and engineering paradigms, its consequential impact on decision making (and by extension, problem solving), and the engagement with empathy, and thus, a human-centred designing task.

In the future, we aim to repeat the study, collecting additional data on the students’ personal values using Schwartz’s Portrait Values Questionnaire-Revised (PVQ-R) [75], [76], and empathy measurements using the (IRI) scale [94], prior and/or during the intervention. We hope to repeat it as part of a longitudinal study, by collecting students’ insight on such a topic
months after the task/intervention, to deduce the longevity of such experiment. We also aim to have individual task settings (instead of group settings), thus to be able to qualitatively analysing results to get a better insight into if and how primes impact students’ designs, with individual additional information on personal values and empathy measures. This, we think, could lead to better insight on the influence of personal values on engineering design, decision making, problem solving, and engagement with socially-related projects. Further work on this topic is included in [95].

**Limitations**

A limitation of this study is that the Self-awareness and Social-awareness Assessment Instrument responses were anonymised, and therefore could not have been matched (before and after responses), and that the Primed (P3) and NonPrimed (P1-Control) groups could not have been split and tested in two separate rooms due to room availability.

The sample size was relatively small, especially when one group’s responses – the Middle (P2) group – had to be disregarded in the analyses. Therefore, more studies need to be carried out for additional data and more robust findings.

The study was carried out in the UK, and since values change across different cultures, it is of interest to consider how these differences in values influence engineering design and SSA results under priming. It would be beneficial to integrate additional demographical factors into the analyses of the study.

Finally, the complex underlying mechanism of priming and its intended triggered consequences are still undergoing extensive neurological research, on their complex relationship with personalities, personal values, intention, cognitive change, behaviour and decision making (see [96] for more information). Any further work expanding on this topic of priming in engineering settings should take note of contemporary psychological and neurological research as the field advances, when designing methodological approaches.
References


Result Tables:

Table 1: SSA Instrument Results of the Primed (P3) group only – before versus after engagement with the Human-Centred Designing Task.

<table>
<thead>
<tr>
<th>Statements (Indicators)</th>
<th>Primed Group (P3) (Before Task) (N =24)</th>
<th>Primed Group (P3) (After Task) (N =17)</th>
<th>Mann Whitney-Significance in before/after results – P3 group only.</th>
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<td>17.54</td>
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<td>3.75</td>
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<td>22.23</td>
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<td>3.57</td>
<td>1.409</td>
<td>21.83</td>
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Table 2: SSA Instrument Results of the NonPrimed (P1) group only – before versus after engagement with the Human-Centred Designing Task.

<table>
<thead>
<tr>
<th>Statements (Indicators)</th>
<th>NonPrimed Group (P1) <em>(Before Task)</em> <em>(N = 30)</em></th>
<th>NonPrimed Group (P1) <em>(After Task)</em> <em>(N = 34)</em></th>
<th>Mann Whitney-Significance in before/after – P1 group only.</th>
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Table 3: SSA Instrument Results before engagement with the Human-Centred Designing Task only – Primed (P3) group versus the NonPrimed (P1) group results.

<table>
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<tr>
<th>Statements (Indicators)</th>
<th>Primed Group (P3) (Before Task) (N = 24)</th>
<th>NonPrimed Group (P1) (Before Task) (N = 30)</th>
<th>Mann Whitney-Significance in P1/P3 groups – before HCD Task only.</th>
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*Emboldened p-values indicate significance; (*) indicate p < .05 and (**) indicate p < .01*
Table 4: SSA Instrument Results after engagement with the Human-Centred Designing Task only – Primed (P3) group versus the NonPrimed (P1) group results.

<table>
<thead>
<tr>
<th>Statements (Indicators)</th>
<th>Primed Group (P3) (After Task Only) (N =17)</th>
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<th>Mann Whitney-Significance in P1/P3 groups – after HCD Task only.</th>
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Emboldened p-values indicate significance; (*) indicate $p < .05$ and (**) indicate $p < .01$