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ORIGINAL PAPER

Don't let perfect be the enemy of good: how perfectionism influences human-centred designing engagement and communal design production in civil engineering

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Abstract
Perfectionism is a personality trait associated with a desire for flawlessness, high-standard expectations and criticism of the self and others. As engineering design seeks to address more wicked problems that move beyond technical considerations, it is possible that engineers with perfectionism may struggle to engage flexibly with complexity and more creativity-focused solutions. The present study seeks to understand perfectionism prevalence in an undergraduate cohort of civil engineers and the impact of this trait on complex design decisions and engagements that include social as well as technical considerations. 184 civil engineering students were involved in this study. We found that 74.5% of the engineers classify as perfectionists, with 68.5% of these perfectionists being maladaptive. Further, we examined how perfectionism associated with *Communal Designs,* a design approach that aims to meet physical community needs as well as more metaphysical, empathy-informed criteria. We found that although perfectionists were more likely to have higher scores of prosocialness and empathy, non-perfectionists were more likely to produce Communal Designs. This suggested an apparent intention-behaviour mismatch. Engineering students may have intended to but then failed to produce Communal Designs; this could also be explained via our finding that perfectionists tend to have higher social desirability scores. The results indicate that complex decision-making in engineering design cannot be separated from the mindsets and personalities of engineers. Strategies to mitigate the negative impact of perfectionism are discussed, including both supported exposure to open-ended, contextualised design, and the use of critical reflection. A regression model predictive of Communal Design production was also developed and discussed using engineering undergraduates' personality characteristics' scores as predictors.

Keywords Civil engineering · Perfectionism · Human-centred design · Design thinking · Personality · Engineering judgement

1 Introduction

The products and processes designed by civil engineers impact society in a variety of direct (e.g., provision of services) and indirect (e.g., impact from pollution, connectivity of communities, and impact on overall health) ways. In recent years, there have been an increasing number of calls for engineers and engineering students to gain a greater understanding and awareness of the social impact and social value of engineering design (AHEP 4 2020; ICE Community blog 2021; ICE usefulprojects 2020; Lawlor 2016; UK-SPEC 4 2020).

The consequences of not valuing social concerns could lead to not valuing and taking into account the opinions and needs of stakeholders in the community, which could negatively impact the design and the community designed for. Therefore, it is of concern that a contemporary body of evidence indicates that engineers devalue social concerns over the course of their studies and careers (Bielefeldt 2018; Bielefeldt and Canney 2016; Cech 2014). It is thus of interest to the field of Civil Engineering and broader

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society to understand what drives this devaluing of social concerns that lie in opposition to the stated desire of the sector to improve engagement with social responsibility.

An example of this can be found in Fitton and Moncaste's (2019) study, where three detailed case studies of flood alleviation projects in England, UK, were examined. Commenting on the data they obtained from speaking with engineers and community members involved in these case studies, they highlighted a seemingly authoritarian engineering manner of decision-making. They point out an engineer's apparent reluctance to decentralise the decision-making power over to the local community members in one of the case studies, and as a result of that, the community was adversely affected.

Zamojska and Próchniak (2017) stated that social costs and benefits from impact remain challenging to predict and quantify, and may be perceived differently by authorities, decision-makers and project developers. They, therefore, emphasise the differential role engineers' individualistic characteristics and attitudes may play in the design judgement and decision-making process.

Gajanayake et al. (2021) designed a decision-making aiding tool that assesses the social, economic, and environmental expenses for a disaster-induced bridge failure reconstruction project. They found that 25–30% of the total impacts of the bridge failure account for socio-economic and environmental impact. They suggest including a comprehensive range of sustainability impacts in the decision-making phase during reconstruction, as they warn that only considering economic ones would lead to suboptimal social outcomes.

Reasons for the tension between the stated aims of the sector to meet societal needs and the evidence that that does not always happen, appear to have multiple contributing factors. One factor could be the lack of training engineers and engineering students receive in working and engaging with such public welfare considerate initiatives (as criticised by Cech (2014) and others). Another factor, we argue, can be due to the engineers' innate drive to work and engage with such initiatives.

In this paper, we assess whether perfectionism in civil engineering students influences design decision-making and judgement, engagement with human-centred and public welfare considerate initiatives, and subsequent production of *Communal Designs*.

This paper argues that perfectionism (i.e., "the tendency to believe there is a perfect solution to every problem, that doing something perfectly (i.e., mistake-free) is not only possible, but also necessary, and that even minor mistakes will have serious consequences" (OCCWG 1997)) and positivism (i.e., the tendency to "take a realist position and assume that a single, objective reality exists independently of what individuals perceive" (Hudson and Ozanne 1988, p. 509; see also Bagozzi 1980; Burrell and Morgan 1979; Morgan and Smiricich 1980), resonate in the manner of problem-solving—they both pursue *the* single, unflawed, correct solution.

Given that engineering paradigms are predominantly positivistic in nature (Downey and Lucena 2003; Erden 2003), and the alignment with perfectionism, this paper hypothesises that engineering students may be perfectionists, as opposed to non-perfectionists, and proceeds to test for it. This paper also tests for the association of perfectionism to empathy and prosocialness (i.e., characteristics that are thought to be positively associated with human-centred designing ethos), and subsequent production of what we term, *Communal Designs.*

Communal Designs are considered a specific form of human-centred, human-need-based design, characterised by the particular attention to needs that involve and encourage end-users' communal engagement and interaction, sense of 'togetherness', and social identity. It is, therefore, the result and manifestation of the empathy, social consciousness, and communal values present in engineers or engineering students.

In the current study, Communal Designs are characterised by the consideration of selected interaction-orientated human needs from Max-Neef et al.'s *Matrix of Human Needs and Satisfiers* (1991, pp. 32–33; see Table 1). If a design considered and addressed peoples' needs but did not address the interaction needs in Table 1, it was discounted as a Communal Design. Communal Designs are thus inclusive of both metaphysical human needs as well as their physical ones (e.g., shelter and sanitation); see (Al Kakoun et al. 2021a, b, p. 13) for more information. The concept of Communal Designs aligns with the calls proposed by the Institute of Civil Engineers (ICE Community blog 2021) and the UK Government (HM Government, Department for Digital, Culture, Media and Sport 2018, pp. 36–45) for implementing

Table 1 Criteria for Communal Design; from (Al Kakoun et al. 2021a, b, p. 13; citing Max-Neef 1991)

Needs according to axiological categories:	Needs according to the existential category: "Interacting"
"Protection"	Box 8: "Living Spaces, social environment, dwelling"
"Participation"	Box 20: "Setting of participative interaction, parties, associations, churches, communities, neighbourhoods, family"
"Idleness"	Box 24: "Privacy, intimacy, spaces of closeness, free time, surroundings, landscapes"

strategies to 'design out loneliness' and achieve 'a connected society', respectively. Declaration of Communal Designs will be further addressed in the Methodology section.

Social desirability, i.e., "the need of Ss [subjects] to obtain approval by responding in a culturally appropriate and acceptable manner" (Crowne and Marlowe 1960, p. 353), will also be tested in civil engineering students. This is to observe the engineering students' intrinsic, as opposed to extrinsic, motives for the responses and designs they present; and also, to reason if an intention-behaviour gap arises, shall it arise. Al Kakoun et al. (2021a, b) addressed an apparent dissonance, or intention-behaviour gap, surfaced in civil engineering students who perhaps intended to, but then failed to produce Communal Designs as part of a human-centred designing assignment.

2 Research questions

RQ2: How does perfectionism associate with *Communal Design* Production?
RQ3: How does perfectionism associate with other characteristics (like prosocialness and empathy) that are known to be positively associated with human-centred designing engagement and thus Communal Design production?
RQ4: How does Communal Design production and perfectionism associate with Social Desirability scores—thus, with the intrinsic or extrinsic motives of the engineering students for the design?

3 Literature review

3.1 Perfectionism

Perfectionism has been defined as "the tendency to believe there is a perfect solution to every problem, that doing something perfectly (i.e., mistake-free) is not only possible, but also necessary, and that even minor mistakes will have serious consequences" (OCCWG 1997).

Perfectionists were described as those "constantly on the alert for what is wrong and seldom focuses on what is right. He looks so intently for defects or flaws that he lives his life as though he were an inspector at the end of a production line" (Hollender 1965, p. 95), and who "set unrealistically high standards, rigidly adhere to them, interpret events in a distorted manner, and define themselves in terms of their ability to achieve their goals" (Burns 1980). Hollender (1965, p. 94) also described a perfectionist as one who is "not likely to be a creative person who changes the world in which we live, he is likely to be a painstaking worker who performs services and turns out products we value".

Perfectionism is said to be *multidimensional* (Hewitt and Flett 1991; Hewitt et al. 1991), and with positive (*adaptive)* and negative (*maladaptive)* sides to it (Slaney and Ashby 1996; Slaney et al. 2001).

Hewitt et al. (1991), the creators of the *Multidimensional Perfectionism Scale (MPS),* discuss perfectionism in terms of its *multidimensions*: *Self-Oriented Perfectionism, Other-Oriented Perfectionism,* and *Socially Prescribed Perfectionism.* They define these dimensions with regard to the motives and drivers for such consequential perfection. Thus, from such understandings, they are also indicative of whether the strive for perfection is intrinsic or extrinsic. Self-oriented perfectionism is defined by a person's high self-standards and high motivation to achieve perfection. Other-oriented perfectionism is defined by a person's expectations of others to perform in a perfectionistic manner, and socially prescribed perfectionism is defined by one's belief that others are imposing their perfectionistic standards upon them, expecting them to be perfect (Hewitt and Flett 1991; Hewitt et al. 1991).

Slaney et al.'s (2001) *The Almost Perfect Scale* (APS-R) differentiates perfectionists from non-perfectionists, and maladaptive perfectionists from adaptive ones. These differentiations are made using responders' self-reported scores on the *Standard* and *Discrepancy* scales of the APS-R. Those who rank highly on the *Standard* scale but low on the *Discrepancy* scale are considered adaptive perfectionists, whilst those who rank highly on both the *Standard* and *Discrepancy* scales are considered maladaptive perfectionists. Those who do not rank highly on the *Standard* scale are considered non-perfectionists. Adaptive perfectionism is defined by a person's strive to be perfect and perform perfectly accompanied by the belief that they can or are able to reach said perfection, whilst maladaptive perfectionism is defined by a person's strive for perfection but is accompanied by their disbelief of reaching said perfection (Bieling et al. 2004; Blankstein et al. 2008; Enns and Cox 2002; Rice and Ashby 2007; Slaney et al. 2001). Rice et al. (2016) describe adaptive and maladaptive perfectionism as "two sides of the same (high) standards coin".

4 Perfectionism's influence in the academic, professional and social settings

Adaptive perfectionists were found to have better career decision-making self-efficacy compared to maladaptive perfectionists and non-perfectionists (Ganske and Ashby 2011), and socially prescribed perfectionism was found to be associated with inferior problem-solving orientation (Flett et al. 1996). Maladaptive perfectionism positively associated with cognitive test anxiety, and thus negatively with academic performances in university students (Eum and Rice 2011); whilst in STEM disciplines, "low-stressed adaptive perfectionists followed by moderately stressed maladaptive perfectionists" were found to have relatively higher GPA scores than their peers (Rice et al. 2015).

With regard to how perfectionism manifests in the social context, perfectionists (both adaptive and maladpative) were found to have higher social perspective-taking scores (i.e., "the ability to judge a situation from the perspective of another person") compared to non-perfectionists (Gilman et al. 2014). Adaptive perfectionists, followed by maladaptive perfectionists and non-perfectionists, were also found to have higher positive interpersonal relationships (Gilman et al. 2010). Gilman et al. (2010) further state that "peers rated both perfectionism groups as more prosocial and less disruptive than nonperfectionists", and that "adaptive perfectionists were more liked than maladaptive perfectionists".

On the other hand, Hewitt et al. (2006; 2017) address a positive association between perfectionism and interpersonal hostility and social disconnection; although this was critiqued by Stoeber et al. (2017), when found that only other-oriented and socially prescribed perfectionism showed associations with signs of hostility and social disconnection, and that self-oriented perfectionism contrastingly showed associations with signs of social connection and low hostility (particularly regarding physical aggression and spitefulness). Moreover, higher levels of *aggression behavior* (i.e., "anger, hostility, physical aggression, and verbal aggression") were found reported by adolescent maladaptive perfectionists, compared to non-perfectionists and adaptive perfectionists, respectively (Ruiz-Esteban et al. 2021).

On another note, Louis and Kumar (2016) found that there exists a "significant number of maladaptive perfectionists" in engineering, and that "they [maladaptive perfectionists] experienced higher levels of personal and societal demands leading to a negative emotional well-being in comparison to the adaptive perfectionists". Additionally, it has been regarded that perfectionism was rather encouraged in engineering education, as "50% good enough will not be acceptable in industry" (Guzzomi et al. 2015).

5 Human-centred designing, empathy and creativity in engineering

5.1 Call for human-centred designing

There have been calls for the integration of more empathy-informed, socially conscious, and public welfare considerate initiatives in engineering and engineering education (Cech 2014; ICE Community blog 2021; ICE usefulprojects 2020; Kouprie and Visser 2009; Lawlor 2016; Leonard and Rayport 1997; Leydens and Lucena 2017; Maguire 2001; Riley 2008);and a similar call for a relative framework called 'Design Thinking' (Cross 2023). These calls have been reflected in the recently updated versions of the United Kingdom's Standard for Professional Engineering Competence and Commitment (UK-SPEC 4 2020), and Accreditation of Higher Education Programs (AHEP 4 2020), where engineers and engineering curriculums are now required to implement and display sustainable thinking in their practice, to comply with the UN's Sustainable Development Goals framework (AHEP 4 2020; Engineering Council | Guidance on Sustainability for the Engineering Profession 2021; UK-SPEC 4 2020).

Multiple UN agencies implemented frameworks of Human-centred designing and Design Thinking to solve complex and wicked problems when pursuing their Sustainable Development Goals (Cserhati 2019; UN Sustainable Development Goals | UNESCO Report 2016; UNICEF 2016; UNICEF | Human Centred Design 4 Health; UNICEF | Office of Innovation; United Nations Development Operations Coordination Office 2016).

These frameworks are known to be powered by social engagement, intuition and empathy (Giacomin 2014), and creativity (Brown 2008; IDEO U 2022; IDEO, Design Thinking; IDEO.ORG); and human-centred designing is driven by the motive of positively impacting the lives of those designed for by putting their needs at the core of the design process (IDEO.ORG; Giacomin 2014; Walters 2005). Moreover, there has been discourse on the economic benefit of human-centred designing and design thinking (ATKINS | The Economic Benefits of Human-Centred Design; IDEO, Design Thinking; UNICEF | Human Centred Design 4 Health; Von Hipple 2007), and the positive association between designing and emotions (Ge et al. 2021).

5.2 Issue: positivism in the face of empathy, and perfectionism in the face of creativity

Positivism is the dominant problem-solving paradigm in engineering education, due to its dominant reliance on scientific and mathematical learning (Downey and Lucena 2003; Erden 2003), and is argued to be 'captivating' social consideration in engineering education, and as it is carried forward into practice (Johnston et al. 1996). This is because positivism tends to reject metaphysical input (Ayer 1936; Hume 1748; Weinber 1936), and thus by extension, emotional, empathy-informed ones, during phases of problem-solving and decision-making. This suggests that positivism may stand in the face of empathy-informed human-centred designing. Moreover, such rejections have been seen in the findings of Al Kakoun et al. (2021a, b), where engineering students' social consciousness scores significantly declined when primed with empathy during a human-centred designing assignment, and in Niles et al. (2018; 2020), where engineering students showed resistance to social engagement and public welfare considerations. Data collected by Guanes et al. (2022) revealed a disconnect between students expressing empathic approaches to engineering matter, which contrasted with the relative absence of adoption of empathic approaches in their capstone projects.

On the other hand, creativity is said to be hindered by perfectionism (Goulet-Pelletier et al. 2021); although the association of creativity and perfectionism was said to be dependent upon the subcategory of perfectionism in discussion as adaptive perfectionism was found to be associated positively with creativity, whilst maladaptive perfectionism either associated negatively, or not at all, with creativity (Wigert et al. 2012). It is therefore clear how perfectionism too may stand in the face of design thinking and human-centred designing. Moreover, in addressing the difficulty of incorporating design thinking in fields like engineering, Elsbach and Stigliani (2018, p. 2295) state that "cultures based on the values of productivity, perfectionism, and siloed specialisation are likely to impede the implementation of design thinking in an organisation"—reasons for this, however, are still yet to be addressed; hence the scope of the current study is to address how (if) engineering mindsets and traits (here, particularly perfectionism) may be determinant of design solution decision-making and judgement in spaces of societal considerations.

5.3 Hypotheses and research questions

As previously stated, the current study argues that positivistic approaches to problem solving and decision-making highly resonate with those of perfectionism—they both pursue *the* single, unflawed, correct solution. From this, we hypothesise that engineering students are likely to be perfectionists, rather than non-perfectionists (H1).

Moreover, based on notions of positivism in the face of empathy, and perfectionism in the face of creativity, we hypothesise that perfectionists are therefore less likely than non-perfectionists to 'fully' engage with the human-centred designing assignment (H2-i), and are thus less likely to produce Communal Designs (H2-ii).

Note that by extension to empathy as a prerequisite to human-centred designing, this paper observes the role of prosocialness and its association with human-centred designing engagement and Communal Design production—as Prosocial Behaviour is connected to human-centred designing through principle of positively enhancing the welfare of other organisms (Cronin 2012). Prosocial behaviour was also found to positively associate with empathy (Eisenberg and Miller 1987).

6 Methodology

The present methodology has been adopted from (Al Kakoun et al. 2021a, 2021b), with slight modifications on the medium of delivery and duration of the human-centred designing assignment workshop. Note that this paper does not cover the priming methodologies used in (Al Kakoun et al. 2021a, 2021b).

6.1 Framework of the human-centred designing assignment and the use of Max-Neef's matrix of human needs and satisfiers

A workshop was set for an undergraduate cohort of civil engineering students to work on a human-centred designing assignment. The assignment involved a case study of two neighbouring districts in Beirut, Lebanon—Hamra and Shatila. Hamra is a prosperous area of Beirut with adequate infrastructure and planning and is considered a 'cultural hub', and Shatila is a refugee camp that was initially designed for 3000 people but is now accommodating 40,000 (Sharif 2018). The workshop was five continuous hours long, online, with questions delivered through *Canvas*, and live lecturer supervision via *Zoom*.

Ultimately, students were expected to deliver a conceptual design that accommodated the needs of Shatila's residents. Given that the engineering student could not have met with the Shatila residents in person (for health and safety purposes—especially during times of COVID-19), they were given other forms of informatic basis to work with; those of which, this study argues, would aid them in their identifications of the needs and problems to be dealt with and designed for later on.

Although Hamra and Shatila are geographically adjacent, they are distinctly different in terms of structural mapping, integrity and planning. These differences were made visible as their consequences were reflected in the statistical quality of life reports provided (i.e., numerical data on the healthy versus the ill, the educated versus the uneducated, the employed versus the unemployed, for example) of the residents of either district. The quality of life reports were intended to provide an indication (in the form of numerical data) reflecting the wellbeing and life satisfaction of the residents.

The engineering students were given plans, maps, residential listings and their forms of occupation (i.e., domestic or business), along with quality of life reports of both districts. The intention was for the maps, plans, information on structural integrity, and building form of occupation (domestic or business) of either district—which are all the resulting works of engineers and designers—to show

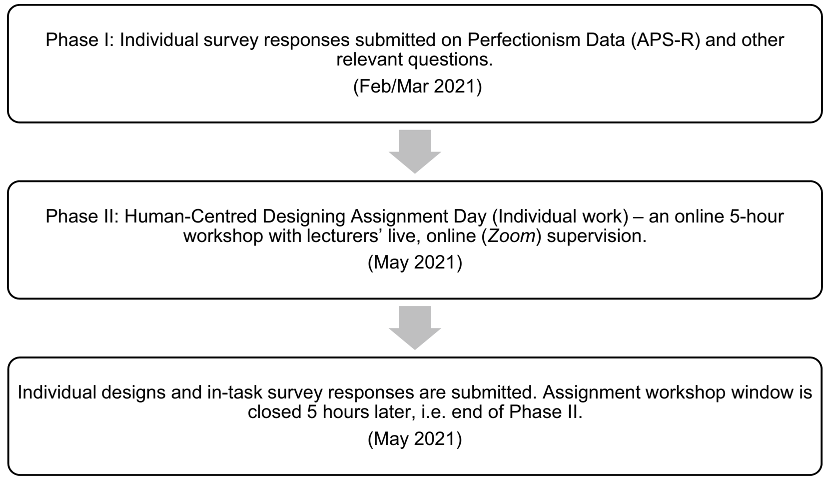

Fig. 1 Study procedure overview

how they may have influenced (either helped or inhibited) some of the residents' needs from being met, and therefore affecting their quality of life, which was then reflected in their quality of life statistical reports.

The students were also given a *Matrix of Human Needs and Satisfiers* (Max-Neef et al. 1991), for them to all have a common and objective baseline of the human needs that generally need to be met for people (particularly those designed for) to live a satisfactory life. This was to objectively generalise and eliminate, as much as possible, engineers' biases imposing their 'personal norms' of what a satisfactory life ought to look like. The *Matrix* therefore conveniently acts as framework that informs engineers with an objective baseline of human-needs to work with and consequentially aids them with identifying the needs lacking in real-life scenarios (such as the case proposed here), and bypass possible subjective bias on what a 'normal satisfactory life' ought to be.

Another reason for the use of the *Matrix* is to escape the pre-set order of needs to be met. This study argues that via the usage of the *Matrix of Human Needs and Satisfiers* in human-centred designing, as opposed to *Maslow's Hierarchy of Needs* (Maslow 1943) (—as seen in Zhang and Dong (2009) study), would nudge the engineering students into considering and regarding all human needs (both physical and metaphysical) in a more lateral and inclusive manner, as opposed to the pre-prioritised, hierarchal, and less liberally inclusive manner seen in *Maslow's Hierarchy of Needs*. Moreover, this study argues that via the usage of *Maslow's Hierarchy of Needs*, students are by default set in a position to be more considerate of the physiological needs (i.e., the basic, physical needs (Maslow 1943, p. 372)); and given the nature of civil engineering practice, they would naturally be more focused on the construction of varied structures and infrastructure that essentially serving the basic needs. This, this paper argues, would then result in engineering students expecting the 'higher' needs (i.e., the more metaphysical, psychological, social needs (Maslow 1943, p. 375)) to later manifest with time and usage of the end-products constructed, and not actively design for them. Therefore, the use of the *Matrix*, this study argues, would nudge the engineers to consider and actively design for all needs in a more lateral and inclusive manner, as this supports the notion "that metaphysical human needs are just as important as basic physical needs when considering human-centred design in engineering settings" (Al Kakoun et al. 2021a, 2021b, p. 7).

On another note, the usage of Max-Neef's et al.'s *Matrix*, as opposed to Maslow's *Hierarchy of Needs*, would also allow the researchers and evaluators of the designs produced by the engineering students, to understand how the students' individualities, characteristics, values, and priorities may have been translated and reflected in the designs they produce, and how/what values and needs are prioritised or disregarded, in their designs.

6.2 Procedure

Prior to the commencement of the Human-Centred Designing Workshop, the engineers were requested to each fill in an *Almost Perfect Scale-Revised (APS-R)* (Slaney et al. 2001)—this was Phase I (see Fig. 1). Note that questionnaire completion was voluntary in Phase I.

A few months later, the Human-Centred Designing Assignment workshop was set—this was Phase II of the study (see Fig. 1). During Phase II, the engineers commenced working on the assignment (the case of Hamra and Shatila). The Human-Centred Assignment was composed of two segments, Part A and Part B.

During Part A of the assignment, the engineering students were instructed to compare the two districts' plans, maps, and information, to distinguish how human needs have already been met and addressed in either district, and identify how that has been reflected in the quality of life reports. Part A was done to prepare the students for Part B of the assignment, which was to define the needs not being met in Shatila, essentially guiding the student into identifying the issues present in Shatila, those of which to be resolved by them as civil engineers, and then proceed to propose a conceptual design to do so. No detailed design was required in this assignment, as the idea was to observe what notions and importance(s) engineers and engineering students give value to when designing and solving for the enhancement of quality of life.

During Part B, the engineering students 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 them 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." (Al Kakoun et al. 2021a, 2021b, pp. 8–9).

Note that both Part A and Part B of the assignment took place in Phase II (see Fig. 1).

Directly after the students' submission of their proposed human-centred designs, they were requested to each fill in a questionnaire on Prosocialness (Caprara et al. 2005), Empathy (Ingoglia et al. 2016), Social Desirability (Reynolds 1982) and Multidimensional Perfectionism (Hewitt et al. 2008). This also took place in Phase II (see Fig. 1). Note that questionnaire completion was voluntary in Phase II.

Designs collected at the end of the workshop were qualitatively determined to be Communal Designs or not. In the present study, the characterisation process of Communal Designs is simple: two independent judges blindly qualitatively analyse the designs provided by the students, declaring them to be Communal Designs if they were inclusive of needs related to those specified in Table 1, or declared 'Not Communal Designs', if they do not include the criteria addressed in Table 1. If a design considered and addressed peoples' needs but did not address the interaction needs in Table 1, it will be discounted as a Communal Design. Communal Designs are thus inclusive of both metaphysical human needs as well as physical ones (e.g., shelter and sanitation), and are distinguished by the intention explicitly expressed in the design for people to meet and interact and obtain a social identity as a result of the solution or design provided. Communal Design declarations of the two blinded independent judges were cross-checked for verification.

Phase II lasted five hours, with assignment delivery via Canvas, and live online lecturer supervision via *Zoom*.

6.3 Participants

This case study involved 184 civil engineering undergraduate students (14.1% female, 1.1% non-binary; and 21.2% international students).

6.4 Instruments

The *Revised Almost Perfect Scale (APS-R)* (Slaney et al. 2001) measures the *Standard* and the *Discrepancy* subscales of perfectionism, based on which the responders are then classified as *adaptive* perfectionists, *maladaptive* perfectionists, or non-perfectionists. The APS-R also measures Order Scales, but these were disregarded, as they do not contribute to the synopsis or hypotheses to be tested in this study.

The *Prosocianlness Scale for Adults* (Caprara et al. 2005) measures "four fundamental aspects of prosocialness, namely, behaviors of helping, sharing, taking care of, and feeling empathic with others" (Caprara et al. 2005, p. 88). The 'Prosocialness' Score of the responder was computed by averaging his/her responses.

The *Interpersonal Reactivity Index on Empathy (IRI) Scale* (Davis 1983) measures four aspects of empathy, namely, Empathic Concern ('other-oriented' empathy), Personal Distress ('self-oriented' empathy), Perspective Taking, and Fantasy. In the present study, 16 out of the 28 items were used as a shorter form of the IRI scale; this Brief Interpersonal Reactivity Index was established and confirmed by Ingoglia et al (2016).

The *Multidimensional Perfectionism Scale—Short Form (MPS-SF)* (Hewitt et al. 2008) is a short version of the *Multidimensional Perfectionism Scale* (Hewitt and Flett 1991; Hewitt et al. 1991). The MPS-SF measures three dimensions of perfectionism, namely, *Self-Oriented Perfectionism*, *Other-Oriented Perfectionism*, and *Socially Prescribed Perfectionism.*

The *Marlowe-Crowne Scale—Reynolds's Form C* (Reynolds 1982) is a short version *The Marlowe—Crowne Social Desirability Scale* (Crowne and Marlowe 1960). These scales measure how socially desirable (or complying to a more socially preferable) responses provided by a responder are. Social Desirability indicates "the need of Ss [subjects] to obtain approval by responding in a culturally appropriate and acceptable manner" (Crowne and Marlowe 1960, p. 353), in other words, taps into how *true* (and intrinsic as opposed to extrinsic) the motivation for the responses of the responder(s) are. High social desirability scores are therefore here interpreted as an indication of a less intrinsic and more extrinsic (or 'imposed upon') driving motivation for the responses/designs provided by the engineering students.

7 Results

A total of 145 survey responses were collected in Phase I, and a total of 184 designs followed by a total of 179 survey responses were collected at the end of Phase II of the workshop (see Fig. 1). Note that as responding to the questionnaires was made voluntary, the response rates could not have been controlled nor paired (with other questionnaire responses, or the number of designs produced); therefore, matching the responses collected in Phase I to those collected in Phase II and the designs produced, has reduced the number of counts involved in the statistical tests computed.

Cut-off points used to classify perfectionists (maladaptive and adaptive) from non-perfectionist in Phase I (see Fig. 1), were adopted from (Gilman et al. 2010). The cut-off points were: Standard Scale score ≥ 37 to be declared a perfectionists (as opposed to a non-perfectionists), along with (if declared perfectionist) a Discrepancy Scale score ≥ 42 to be declared a maladaptive perfectionist (as opposed to an adaptive one).

Pearson chi-square tests were computed to test for the statistical significance of the relationships between the categories addressed (Fisher 1922; Pearson 1900); similarly, Fisher exact tests will be used to assess for the significance of the relationships between categories whenever there is a categorical count less than 5 (Fisher 1922). Statistical analyses resulting in p-values <0.05 are considered statistically significant, whilst those resulting in p-values <0.1 can be argued to be 'tending-to-be significant' (see Andrade 2019; Thiese et al. 2016; Benjamin et al. 2018) for more information). Moreover, note that in this study, results addressing 'higher-than-average' and 'lower-than-average' scores imply that the scores in the discussion are higher than the average score of the group involved, or lower than it, respectively.

A factor analysis followed by a binary logistic regression was computed to assess how the personal characteristics addressed (like perfectionism, empathy, prosocialness, and social desirability) simultaneously contribute to, or associate with the probability of Communal Design production (as opposed to how they individually associate with Communal Design production—like what will be observed as a result of the chi-squared tests). Results are displayed in the same order as the research questions proposed. Result tables referred to in this section can be found in the appendix.

RQ1. How common is perfectionism amongst civil engineering students?

74.5% of civil engineering students were found to be categorised as perfectionists—with 68.5% of the perfectionists being maladaptive, and only 31.5% being adaptive (see Table 2). These results indicate that the majority of civil engineering students indeed tend to hold perfectionistic traits, thus supporting our first hypothesis proposed (H1).

For further efficiency and simplicity of result display and analysis, results thereafter will be addressed with regard to a 'Non-Perfectionist' as opposed to a 'Perfectionist' category—thus, maladaptive and adaptive perfectionists' results will be combined into one 'Perfectionists' Category.

RQ2. How does perfectionism associated with *Communal Design* Production?

Via computing a Pearson chi-square test, we tested the relationship between perfectionism and the production of Communal Designs and found it to be statistically significant (X^2 $(1, N=145)=7.767, p=0.005$); perfectionists were found less likely than non-perfectionists to produce Communal Designs (see Table 3). These results thus support the latter part of the second hypothesis (H2-ii).

RQ3. How does perfectionism associate with other characteristics (like prosocialness and empathy) that are known to be positively associated with human-centred designing engagement and thus Communal Design production?

Via computing a Fisher exact test, we tested the relationship between perfectionism and prosocialness scores during the students' production of Communal Designs, and found it to be statistically significant($p<0.05$); perfectionists were found more likely than non-perfectionists to produce Communal Designs whilst having higher-than-average '*Prosocialness'* scores (see Table 4).

Similarly, via computing Fisher exact tests, we tested the relationship between perfectionism and the different facets of empathy; it was found that perfectionists were more likely than non-perfectionists to produce Communal Designs whilst having higher-than-average '*Empathy: Empathic Concern'* scores ($p<0.05$), and '*Empathy: Fantasy'* scores ($p<0.05$) (see Tables 5 and 6, respectively). No significant associations were found between the subjects' perfectionism, Communal Design production, and Empathy: Perspective Taking scores (see Table 7) nor Empathy: Personal Distress scores (see Table 8).

These results are interesting, as they defy the first part of the second hypothesis (i.e., H2-i); contrary to what was hypothesised, it was found that perfectionists were more likely than non-perfectionists to show signs of engagement (i.e. showed higher empathy and prosocialness scores) with the human-centred designing assignment.

RQ4. How does Communal Design production and perfectionism associate with Social Desirability scores—thus, with the intrinsic or extrinsic motives of the engineering students for the design?

Via computing Pearson chi-square tests, we tested the relationship between perfectionism and social desirability scores during the students' production of Communal Designs and found it to be not statistically significant (X^2 (1, $N = 49$) = 2.119, $p = 0.145$) (see Table 9). However, when tested for the relationship between engineers' perfectionism and social desirability in general, it was found tending-to-be statistically significant (X^2 (1, $N = 142$) = 3.497, $p = 0.061$), perfectionists were tending-to-be more likely than non-perfectionists to have higher-than-average *'Social Desirability'* scores in general (see Table 10); i.e., perfectionists were more likely to have responded in a manner that was thought to be socially appropriate, indicating their extrinsic drive for the responses and designs they proposed, as opposed to their *true*, intrinsic motives.

Finally, to observe how personal characteristics collectively associate with Communal Design production, a factor analysis followed by a binary logistic regression was computed. A factor analysis has been computed to test for the suitability of the data collected and to thereafter perform a logistical regression model that predicts students' production of Communal Design based upon their personal characteristics' scores (i.e., predictors') collective and simultaneous influence on the output.

A factor analysis was conducted on the 12 items, or characteristics, (shown in Table 11) with no rotation. The Kasier-Meyer-Olkin measure verified the sampling adequacy for the analysis, KMO = 0.730 (i.e., 'middling' according to Kaiser and Rice (1974)); see Table 12. Moreover, Bartlett's Test of Sphericity shows significance (i.e., $p < 0.001$), indicating that the variables (characteristics addressed) are related and are therefore suitable for further structure detection (Bartlett 1954), or in other words, are suitable to be entered into a binary logistic regression model; see Table 12.

A binary logistic model was developed using the aforementioned 12 characteristics as predictors of Communal Design production. Table 13 shows the number of cases included in the regression is 142 out of 184 (i.e., 42 are missing cases due to the present limitation on matching the responses of Phase I to those of Phase II). The first classification table (i.e., Block 0, null table) shows that before entering the predictors (i.e., the personal characteristics' scores) into the model to predict the probability of producing Communal Designs, the model was able to predict 65.5% of the outputs (see Table 14). However, after entering the predictors, the model was shown to have then been able to predict 71.8% of the outcomes (see Table 15), indicating that the predictive ability was enhanced after entering these variables, or personal characteristics' scores. This was also seen in the Contingency Table for Hosmer and Lemeshow Test (Table 17), where after entering the variables, out of the 12 observed Communal Designs produced, the model successfully predicted 9 of them—the Hosmer and Lemeshow Test showed statistical non-significance ($p = 0.626$) indicating acceptable predictability (see Table 16).

Block 1 Variables in the Equation table (see Table 19) show the different characteristics' 'slopes', i.e.., magnitudes (via observing the coefficients' value, B) and direction (either positive or negative), contributing to the regression line predictive of the probability of Communal Design production. These coefficients can be assembled in an equation that helps predict the probability of Communal Design production (coded 1), or not (coded 0), based on the characteristic scores entered.

Equation 2, assembled based on the generic Eq. 1:

Equation 1*—Generic equation predictive of probability of (y) output*

$$P(y) = \frac{Exp(\beta_0 + \beta X_1 + \beta X_2 + etc.)}{1 + Exp(\beta_0 + \beta X_1 + \beta X_2 + etc.)}$$

(see Field 2018; Sreejesh et al. 2014; Sweet and Grace-Martin 2003) for more information), and the current case study data, is the following:

Equation 2*—equation predictive of probability of communal design production*

$$P(y_{(Communal\ Design\ Production)}) = \frac{Exp(-0.714 - 0.041X_1 + 0.004X_2 + 0.027X_3 + 0.558X_4 - 0.590X_5 + 0.046X_6 + 0.524X_7 + 0.075X_8 - 0.042X_9 - 0.055X_{10} + 0.021X_{11} - 0.040X_{12})}{1 + Exp(-0.714 - 0.041X_1 + 0.004X_2 + 0.027X_3 + 0.558X_4 - 0.590X_5 + 0.046X_6 + 0.524X_7 + 0.075X_8 - 0.042X_9 - 0.055X_{10} + 0.021X_{11} - 0.040X_{12})}$$

where β_0 is the constant; and the β_x's are the values displayed in the 'B' column in Table 19; i.e., X_1= APS-R Standard Scale score, X_2= APS-R Order Scale score, X_3= APS-R Discrepancy Scale score, X_4= Prosocialness Scale score, X_5= Empathy: Empathic Concern score, X_6= Empathy: Fantasy score, X_7= Empathy: Perspective Taking score, X_8= Empathy: Personal Distress score, X_9= Self Oriented Perfectionism score, X_{10}= Other-Oriented Perfectionism score, X_{11}= Socially Prescribed Perfectionism score, and X_{12}= Social Desirability score. It is seen that Empathy: Empathic Concern (X_5), followed by Prosocialness (X_4), were the top two influential characteristics on the probability of Communal Design production in the present study—Empathy: Emapthic Concern contributing with a negative influence, whereas Prosocialness contributing with a positive influence (see Eq. 2).

However, it was found that none of the characteristics had a significant p-value, indicating that the null hypothesis could not have been rejected, and that the characteristics do not have a significant effect on the probability of Communal Design production. This could also be observed under the '95% C.I.for EXP(B)' columns in Table 19, where all confidence intervals cross the value of 1, indicating that the data values entered into the model are equally suggestive of improving or decreasing the probability of Communal Design production (see (Field 2018, p.904) for more information). Moreover, the Nagelkerke R^2 value indicated that only 13.1% of the variance in the production of Communal Design probability can be explained by variances in the 12 predictive characteristics entered into the model (see Table 18), indicating a low fitness of the model.

8 Discussion

Present results revealed that the majority (74.5%) of civil engineering students classify as perfectionist, with 68.5% of these perfectionists being maladaptive, i.e., the 'unhealthy' form of perfectionists (see Table 2). The first hypothesis (H1: engineering students are likely to be perfectionists, rather than non-perfectionists) is therefore fulfilled. This finding supports Louis and Kumar's (2016) indication of the presence of a "significant number of maladaptive perfectionists" in engineering.

Results also indicated that engineering students with higher perfectionistic scores, or being declared as perfectionists as opposed to non-perfectionist, were less likely to produce Communal Designs (see Table 3 These findings therefore support the second part of the second hypothesis (H2-ii: perfectionists are less likely to produce Communal Designs). These results were expected, as the literature indicated that perfectionism hinders creativity (Goulet-Pelletier et al. 2021), which is a prime aspect of design thinking and human-centred designing. It was therefore expected that perfectionistic engineers were less likely to 'fully' engage with the human-centred designing task at hand, and as a consequence, less likely to produce the Communal Designs.

However, what was not expected, was the first part of the second hypothesis (H2-i: perfectionists to be less likely than non-perfectionists to 'fully' engage with the human-centred designing assignment) to be overruled, especially when the resulting product, or the second part of the hypothesis (H2-ii), was fulfilled.

Present findings reveal that although the perfectionist were found less likely to produce Communal Design (fulfilling H2-ii), they were found more likely to have higher scores of prosocialness, empathy, empathy: empathic concern and empathy: fantasy when producing the Communal Designs (compared to the non-perfectionists) (see Table 4, Table 5 and Table 6, respectively). This not only defies the first part of the second hypothesis (H2-i) but also indicates that perfectionists were more likely to show signs of more engagement (via engaging more empathically and prosocially) with the human-centred design initiative. Supporting these surprising findings, are the findings of Gilman et al. (2014) and Gilman et al. (2010) on perfectionists having higher social perspective taking (which is a form of empathy (Davis 1983)) and are perceived as more prosocial amongst their peers, respectively. However, contradicting these findings, are of Hewitt et al. (2006; 2017) and Ruiz-Esteban et al. (2021) on perfectionists' positive associations with interpersonal hostility and social disconnection, and *aggression behavior*, respectively.

This study interprets this dissonance in perfectionists being less likely to produce Communal Designs, but simultaneously more likely to 'fully' engage with the design initiative, hinting towards the findings of Al Kakoun et al. (2021a). Al Kakoun et al. (2021b) addressed an apparent dissonance, or intention-behaviour gap, in which civil engineers may intend to, but fail to produce Communal Designs. To contextualise, when referring to *intention* in this study, it is interpreted as the intention to produce Communal Design (i.e., by showing higher, intuitive engagement with the human-centred designing initiative), and *behavior* as the actual/eventual production of the Communal Design. In explaining the *Intention-Behavior Gap*, Sheeran and Webb (2016) indicated that people may refrain from acting upon an intention not because they lack motivation or value for it, but rather because they may lack the technical competencies required for acting upon these intentions, motivations and values. This resonates with the discussion of Cech and Sherick (2015) on how the depoliticised nature of engineering education and culture may be hindering engineers' interest and capacity for work and engagement with human-centred, public-welfare-considerate initiatives in engineering—but are still expected to adequately perform their duties consisting them, nonetheless!

Moreover, this dissonance can also be interpreted via the social desirability scores of the engineering students. Social desirability is associated with the "the need of Ss [subjects] to obtain approval by responding in a culturally appropriate and acceptable manner" (Crowne and Marlowe 1960, p. 353). Present results show that perfectionists were tending to have higher Social Desirability scores than non-perfectionists in general (see Table 10). This, therefore, indicates that perfectionists may have likely provided responses reflecting higher prosocialness and empathy due to their general desire to deliver more socially desirable and socially acceptable responses.

On another note, Fermandel (2015) found that perfectionists are likely to hold self-protective and anxiety-avoidant motives and drivers, for persevering "self and existing status quo" and "serving to cope with anxiety". Fermandel's (2015) findings, combined with Fitton and Moncaster's (2019) finding on engineers' undesirability of decentralising the power of decision-making in the design process, reassures this paper's allegation that such conservative act of centralising decision-making power may indeed be defensive, and is predicted to be protective of the engineers' image and 'peace of mind'. This may tap into reasons as to why engineers have, and continue to struggle with the integration of the more complex human-centred consideration into practice; as such wicked problem solving not only demands new, challenging, creative and more complex approaches to problem-solving, it may challenge the current *natural* positivistic state of problem-solving in engineering, and with that, the engineers' 'peace of mind' and status-quo, possibly triggering their anxiety. This could also be an answer to Elsbach and Stigliani's (2018) questioning of why perfectionistic cultures are likely to hinder design thinking.

Additionally, with the present findings show that the majority of civil engineering students are more likely to hold perfectionistic traits (– with a high percentage of them being maladaptive) combined with the extensive research on the negative associations of perfectionism to mental or physical wellbeing (Blatt et al. 1995; DiBartolo et al. 2008; Geranmayepour and Besharat 2010; Molnar et al. 2006), this paper sheds light and recommends engineering cultures and curriculums to actively implement strategies that tend to their subjects' perfectionism and consequential wellbeing. This recommendation also applies to other cultures and paradigms where positivism and perfectionism are known to be predominant—in both the academic and practicing fields. Moreover, this paper recommends interventions to be set for mitigating perfectionism to also facilitate design thinking, engagement with human-centred and public-welfare-considerate initiatives, and Communal Design production in engineering.

Finally, the present findings shed light on the importance of further exploring how influential engineering mindsets and characteristics can be on engineers' decision-making processes, design judgements, and their engagement with human-centred, public-welfare-related initiatives.

In seeking to support perfectionist students, learning and assessment strategies likely require the incorporation of less convergent and more divergent learning methods, together with cognitive tools to support students to recognise and challenge any tendency to perfectionism. The regular use of open-ended and contextualised teaching and learning activities can normalise the consideration of complex, integrated socio-technical design problems. This exposure could make scenarios less daunting for perfectionist students who may enter higher education initially preferring the comfort of a defined answer (as usually experienced in secondary education in STEM). Examples of strategies that appear well suited include the 'Grassroots/ Popular Engineering' related by Cordeiro Cruz (2021) with its commitment to foregrounding equity and liberation in the design process. CDIO (Conceive, Design, Implement, Operate) related by Crawley et al. (2014) is a learning framework that encourages student learning through real design. CDIO advises the building of opportunities to learn iteratively from failure, which could help perfectionist students to reframe failure as a normal part of the learning process rather than interpreting it as a personal deficit. Critical reflection is a pedagogic tool suited to increasing awareness of decision-making through the design process, and offers a chance for students to reconsider their actions, seeking the root causes driving their decision-making (Orbaek White et al. 2020). A useful exercise suited to improving understanding of inclusivity may be to conduct critical reflection on a completed engineering design process together with information about perfectionism and other traits. This could enhance students' reflexive capability to identify how different minds approach the same situation, giving them insight into how their own cognitive processes may differ to others (Table 17).

Lastly, a model predictive of the probability of producing Communal designs was developed using the 12 characteristics addressed in this study, which had showed an acceptable sampling adequacy (see Table 12) after conducting a factor analysis. The model, however, showed low fitness and none of the characteristics showed significance in influencing the outcome (see Tables 18 and 19, respectively). However, the model produced an equation, tailored to the present particular case, that showed that Empathy: Empathic Concern followed by Prosocialness scores were the most influential on the probable outcome of Communal Design production—where Empathy: Empathic Concern contributed negatively to the probability of producing Communal Designs, and Prosocialness contributed positively to the probability of Communal Design production (see Eq. 2).

9 Conclusion and future work

This study assessed the prevalence of perfectionism in an undergraduate cohort of civil engineers, and its potential association with their engagement with a communal, human-centred, social-welfare considerate initiative (Communal Designs*)*. This study found that 74.5% of civil engineering students categorise as perfectionist, with 68.5% of those perfectionists being maladaptive. We found that although perfectionists were less likely to produce Communal Designs, they were still found more likely to hold higher prosocialness and empathy scores during the

Communal Design production process (i.e., showing more engagement with the human-centred designing initiative). This hinted towards an intention-behaviour gap in which engineering students perhaps intended to but then failed to produce Communal Designs that met the metaphysical criteria addressed in Table 1 (extracted from Max-Neef et al.'s (1991) Matrix of Human Needs and Satisfiers). This could plausibly be due to engineering culture's dissonance in training and expectations of performance on societal and public welfare considerate initiatives. This dissonance was also discussed in terms of social desirability, as this study found that perfectionists were tending to hold higher social desirability scores, i.e., were tending to have provided responses reflecting higher prosocialness and empathy due to their desire to deliver what they may consider as more socially acceptable responses to those assessing their work.

We conclude that in the face of ambiguity (often inherent in complex socio-technical design), the power-centralised and conservative engineering design decision-making process may become defensive due to the perfectionist tendencies of self-protection and anxiety-avoidance. This could inform why some engineers struggle to move from rigid and positivist learning and practice to more creative, empathic, human-centred, and socially considerate initiatives. It is recommended to implement strategies in both learning and assessment design to mitigate perfectionism in engineering. Strategies discussed include more regular exposure to contextualised design to normalise complexity and creativity, together with strategies for reflection on how different types of minds may approach a situation in different ways.

Limitations of the study include the small dataset on which these conclusions are based, and as the assessment was held during COVID, the assessment was completed online rather than in person. It would be worthwhile to replicate the study at a greater scale and in more typical conditions to confirm if the association seen in this study remains persistent. Moreover, as responses collected in Phase I of the intervention could not have been matched to those collected in Phase II, the response numbers were reduced further.

Further in future work, to avoid considering factors that are not statistically significant, we will use a more advanced statistical technique, such as LASSO (least absolute shrinkage and selection operator), to reduce the contributing factors to the most significant ones. LASSO will also eliminate any potential factor selection bias, and will therefore produce more concise and objective results. Moreover, we will conduct PCA (principal component analysis) with rotations to eliminate the risk of potential covariations in the dataset.

There is further work required to determine how perfectionist (and other) traits of civil engineers and engineering students compare to those of other disciplines in engineering, or other fields. There is also further work required on what strategies can be used to help student wellbeing and support students to overcome the limitations that perfectionism and maladaptive perfectionism may be placing on achieving fully rounded engineering designs for an equitable society.

Appendix

See Tables 2, 3, 4, 5, 6 and 7.

Table 2 Breakdown of perfectionism categories in civil engineering students

Perfectionism category	Number of Civil Engineering Students (%)
Non-Perfectionists	37 (25.5%)
Perfectionists: Adaptive	34 (23.5%)
Perfectionists: Maladaptive	74 (51.0%)
Total Number of Responses in Phase I	145 (100%)

Table 3 Association of communal design production and perfectionism categories

	No. of '*Communal Designs*' Produced	No. of 'Not *Communal Designs*' Produced	Row Totals
Perfectionists	31	77	108
Non-Perfectionists	20	17	37
Column Totals	51	94	Grand Total = 145

Pearon chi-square test result: X^2 (1, N = 145) = 7.767, p = .005

Table 4 Association of communal design production, prosocialness, and perfectionism categories

	Non-perfectionists	Perfectionists	Row totals
No. of Communal Designs Produced—whilst having higher-than-average '*Prosocialness'* Scores	4	17	21
No. of Communal Designs Produced—whilst having lower-than-average '*Prosocialness*' Scores	15	13	28
Column Totals	19	30	Grand Total = 49

The Fisher exact test statistic value is 0.019. The result is significant at $p < .05$

Table 5 Association of communal design production, empathy: empathic concern, and perfectionism categories

	Non-perfectionists	Perfectionists	Row totals
No. of Communal Designs Produced—whilst having higher-than-average '*Empathic Concern'* Scores	4	18	22
No. of Communal Designs Produced—whilst having lower-than-average '*Empathic Concern*' Scores	15	12	27
Column Totals	19	30	Grand Total = 49

The Fisher exact test statistic value is 0.010. The result is significant at $p < .05$

Table 6 Association of communal design production, empathy: fantasy, and perfectionism categories

	Non-perfectionists	Perfectionists	Row totals
No. of Communal Designs Produced—whilst having higher-than-average '*Fantasy'* Scores	5	20	25
No. of Communal Designs Produced—whilst having lower-than-average '*Fantasy*' Scores	14	10	24
Column Totals	19	30	Grand Total = 49

The Fisher exact test statistic value is 0.009. The result is significant at $p < .05$

Table 7 Association of communal design production, empathy: perspective taking, and perfectionism categories

	Non-perfectionists	Perfectionists	Row totals
No. of Communal Designs Produced—whilst having higher-than-average '*Perspective Taking'* Scores	12	19	31
No. of Communal Designs Produced—whilst having lower-than-average '*Perspective Taking'* Scores	7	11	18
Column Totals	19	30	Grand Total = 49

Pearon chi-square test result: X^2 (1, N = 49) = 0.000, p = .990

Table 8 Association of communal design production, empathy: personal distress, and perfectionism categories

	Non-perfectionists	Perfectionists	Row totals
No. of Communal Designs Produced—whilst having higher-than-average '*Personal Distress'* Scores	10	15	25
No. of Communal Designs Produced—whilst having lower-than-average *'Personal Distress'* Scores	9	15	24
Column Totals	19	30	Grand total = 49

Pearon chi-square test result: X^2 (1, N = 49) = 0.032, p = .858

Table 9 Association of communal design production, social desirability, and perfectionism categories

	Non-perfectionists	Perfectionists	Row totals
No. of Communal Designs Produced—whilst having higher-than-average '*Social Desirability'* Scores	8	19	27
No. of Communal Designs Produced—whilst having lower-than-average '*Social Desirability*' Scores	11	11	22
Column Totals	19	30	Grand total = 49

Pearon chi-square result: X^2(1, N = 49) = 2.119, p = .145

Table 10 Associations of social desirability and perfectionism categories in civil engineering students

	Non-perfectionists	Perfectionists	Row Totals
No. of engineers with higher-than-average '*Social Desirability'* Scores	16	66	82
No. of engineers with lower-than-average '*Social Desirability*' Scores	20	40	60
Column Totals	36	106	Grand total = 142

Pearon chi-square result: X^2 (1, N = 142) = 3.497, p = .061

Table 11 Factor analysis descriptive statistics

Descriptive statistics			
	Mean	Std. deviation	Analysis N
APS-R Standard Scale	39.64	5.560	142
APS-R Order Scale	20.56	3.900	142
APS-R Discrepancy Scale	50.44	13.163	142
Prosocialness	3.790493	.5454314	142
Empathy: Empathic Concern	3.8363	.70210	142
Empathy: Fantasy	3.0634	1.11900	142
Empathy: Perspective Taking	3.6901	.69887	142
Empathy: Personal Distress	2.5335	.89830	142
Self-Oriented Perfectionism	23.78	6.694	142
Other-Oriented Perfectionism	20.66	5.412	142
Socially Prescribed Perfectionism	22.54	6.422	142
Social Desirability	6.87	2.603	142

Table 12 Factor analysis FMO and Bartlett's test

KMO and Bartlett's test		
Kaiser–Meyer–Olkin Measure of Sampling Adequacy		.730
Bartlett's Test of Sphericity	Approx. Chi-Square	520.691
	df	66
	Sig	< .001

Table 13 Regression cases (N)

Case processing summary			
Unweighted cases[a]		N	Percent
Selected cases	Included in analysis	142	77.2
	Missing cases	42	22.8
	Total	184	100.0
Unselected cases		0	.0
Total		184	100.0

If weight is in effect, see classification table for the total number of cases

Table 14 Block 0 (i.e., before entering variables) classification table; null table

	Observed		Predicted		
			Produced communal design?		Percentage correct
			No	Yes	
Classification table[a,b]					
Step 0	Produced Communal Design?	No	93	0	100.0
		Yes	49	0	.0
	Overall percentage				65.5

[a]Constant is included in the model

[b]The cut value is .500

Table 15 Block 1 (i.e., after entering variables) classification table

	Observed		Predicted		
			Produced communal design?		Percentage correct
			No	Yes	
Classification table[a]					
Step 1	Produced communal design?	No	86	7	92.5
		Yes	33	16	32.7
	Overall percentage				71.8

a. The cut value is .500

Table 16 Hosmer and Lemeshow test

Hosmer and Lemeshow Test			
Step	Chi-square	df	Sig
1	6.188	8	.626

Table 17 Contingency table for Hosmer and Lemeshow test

		Produced communal design? = No		Produced communal design? = Yes		Total
		Observed	Expected	Observed	Expected	
Contingency Table for Hosmer and Lemeshow Test						
Step 1	1	11	12.488	3	1.512	14
	2	12	11.499	2	2.501	14
	3	10	10.809	4	3.191	14
	4	10	10.241	4	3.759	14
	5	11	9.548	3	4.452	14
	6	9	8.910	5	5.090	14
	7	9	8.365	5	5.635	14
	8	10	7.656	4	6.344	14
	9	7	6.892	7	7.108	14
	10	4	6.593	12	9.407	16

Table 18 Fitness of model

Model summary			
Step	-2 Log likelihood	Cox and Snell R Square	Nagelkerke R Square
1	168.868[a]	.095	.131

Table 19 Block 1 variables in the Equation (i.e., weight of parameters in the model after entering the variables)

		B	S.E	Wald	df	Sig	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Variables in the equation									
Step 1[a]	APS-R standard scale	−.041	.047	.792	1	.373	.959	.876	1.051
	APS-R order scale	.004	.057	.004	1	.949	1.004	.897	1.123
	APS-R discrepancy scale	.027	.017	2.598	1	.107	1.028	.994	1.062
	Prosocialness	.558	.444	1.578	1	.209	1.747	.731	4.172
	Empathy: empathic concern	−.590	.382	2.389	1	.122	.554	.262	1.171
	Empathy: fantasy	.046	.215	.045	1	.832	1.047	.687	1.594
	Empathy: perspective taking	.524	.350	2.241	1	.134	1.690	.850	3.357
	Empathy: personal distress	.075	.255	.086	1	.769	1.078	.654	1.776
	Self-oriented perfectionism	−.042	.046	.822	1	.365	.959	.877	1.050
	Other-oriented perfectionism	−.055	.052	1.106	1	.293	.946	.854	1.049
	Socially prescribed perfectionism	.021	.043	.229	1	.632	1.021	.938	1.110
	Social desirability	−.040	.076	.271	1	.603	.961	.828	1.116
	Constant	−.714	2.057	.121	1	.728	.490		

a. Variable(s) entered on step 1: APS-R Standard Scale, APS-R Order Scale, APS-R Discrepancy Scale, Prosocialness, Empathy: Empathic Concern, Empathy: Fantasy, Empathy: Perspective Taking, Empathy: Personal Distress, Self-Oriented Perfectionism, Other-Oriented Perfectionism, Socially Prescribed Perfectionism, Social Desirability

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Declarations

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