Does Empathy Beget Creativity? Investigating the Role of Trait Empathy in Idea Generation and Selection

Mohammad Alsager Alzayed, Scarlett R. Miller, and Christopher McComb

Abstract The ability to understand and feel the needs and circumstances of others, also known as empathy, has been found to help engineering designers develop a deeper understanding of the design problems they solve. While prior work has examined the utility of empathic design experiences on driving creative concept generation, little is known about the role of a designer's empathic tendencies in driving creative idea generation and selection in an engineering design project. Without this knowledge, we cannot be sure if, when, or how empathy influences the design process. Thus, the main goal of this paper was to identify the role of trait empathy in creative concept generation and selection in a humanitarian engineering design student project. In order to achieve this, a study was conducted with 103 first-year engineering students during three design stages of an 8-week design project (problem formulation, concept generation, and concept selection). The results from this research highlighted that empathic concern tendencies predicted the generation of more ideas. In addition, perspective-taking and fantasy tendencies negatively predicted the generation of more ideas. During concept selection, personal distress predicted participants' propensity for the selection of useful ideas while empathic concern negatively predicted the selection of useful ideas. These results present some of the first evidence on the relationship between trait empathy and creativity in the concept generation and selection stages of the design process.

Keywords Empathy · Idea generation · Creativity

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1 Introduction

Over the past decade, engineering design research has seen a significant surge of the discussion of empathy [1], or one's ability to understand and feel the needs and circumstances of others [2], due to its ability to help engineering designers develop a deeper understanding of the design problem [3]. Empathy may be particularly important in the early conceptual stages of the design process (i.e. problem formulation, concept generation and selection [4]) as it involves a designer's attempt to "relate to [the user] and understand the situations and why certain experiences are meaningful to these [users]" ([5], pg. 67). Investing in these earlier conceptual stages can save costs and effort [6], as the success of a product can be linked to the early conceptual stages of the idea's emergence [7]. Using design effectiveness measures, Genco et al. [8] and Johnson et al. [9] found that empathetic design experiences were an effective method to drive creative outcomes (i.e., originality and quality). In the same line of research, simulating extraordinary user scenarios was effective in enhancing engineering students' empathic self-efficacy as well as the novelty, quantity, and variety of ideas generated by students [10]. While this prior work discussed the promising role of empathy in concept generation, studying the role of empathy in driving creative concept *selection* has been scarcely examined. This is problematic since researchers have identified concept selection as one of the most critical stages that determine successful engineering design [11].

While this prior research indicates empathy may be a *potential* driver of successful engineering design processes, other work [12] warns that empathic design techniques might place designers in the "empathy trap" by triggering popular *directed* reflections from the users instead of providing radical innovations to the existing problems [12]. Additionally, recent research has also identified that engineering faculty may feel that empathy was "a plus but … not what is really necessary to be a good engineer" ([13], pg. 149). In the same line of research, engineering students discussed the irrelevance of empathy in engineering due to the technical and analytical nature of the engineering discipline [14].

Taken as a whole, prior research provides conflicting interpretations on the role of empathy in design and the scarcity of research on the role of empathy in concept selection. Without this knowledge, we cannot be sure *if*, *when,* or *how* empathy is important in the design process. Therefore, the main goal of this paper was to identify the role of trait empathy in creative concept generation and selection in an engineering design student project. The results from this research provide some of the first evidence that establishes the relationship between trait empathy and creativity in the concept generation and selection stages of the design process.

2 Related Work

In order to establish the framework for the current investigation, this section highlights prior work on (1) the role of empathy in the design process, and (2) measuring trait empathy.

2.1 The Role of Empathy in the Design Process

Over the past decade, empathy has been found to help engineering designers better understand the needs of users that are different from themselves [15, 16]. Specifically, prior work has shown that developing empathy can help develop a deeper understanding of the design problem [3] and the stakeholders [15] and encouraged an employment of a more targeted user research [16] during the problem formulation stage. Through semi-structured interviews with engineering students, Fila and Hess [14] found empathy to be related to problem contextualization and design inspiration.

Using design effectiveness measures, Genco et al. [8] and Johnson et al. [9] found that empathetic design experiences have been found to be an effective method to drive creative outcomes (originality and quality) in the conceptual design stages. While that prior work found a relationship between empathy and creativity, researchers have found that the creativity of solutions generated by a designer can hinge on the nature of the design task [17], and the designer's personal connection with the end-user [10]. Similarly, Hess and Fila [18] highlighted the impact of the context of the design problem in impacting design outcomes, which this work controlled for.

While previous research has highlighted the effectives of empathic design techniques in the concept generation stages, engagement in empathic design experiences have also received criticism in the literature. For example, Mattelmäki, Vaajakallio, and Koskinen [12] were concerned that designers engaged in empathic design techniques might end up in the "empathy trap"; their attempt to be empathic might trigger popular *directed* reflections from the users instead of providing radical innovations to the existing problems [12]. This has been studied by Chung and Joo [19] that found that engaging designers with an empathic instruction task (watching a video on the end-user) decreased their concept evaluation scores, suggesting a "dark" side to empathy. Breithaupt [20] discusses some of the dark sides of empathy, empathic vampirism [21], where individuals might over-identify with others. In the context of design, that line of research suggests that the designer would end up designing for themselves if they over empathize [21].

While this prior work provides conflicting interpretations on the role of empathy in concept generation, studying the role of empathy in driving creative concept *selection* has been scarcely examined. This is problematic since researchers have identified concept selection as one of the most critical stages that determine successful engineering design [11, 22]. During this stage, designers narrow down the ideas generated during concept generation [4]. Studying designers' creativity during concept generation *solely* is not representative of the designers' creativity since generating creative ideas does not necessarily guarantee the final design's creativity [22]. One way of assessing designers' creativity in the concept selection stage is through their propensity for selecting creative ideas [23, 24]. Prior research by Toh and Miller [4, 25] identified that the cognitive skills used in concept selection are very different from the skills used during concept generation. For example, designers' risk tolerance and team centrality have been found to impact designers' creative concept selection [26], but not necessarily their creative concept generation. In the same line of research, Hay et al. [27] found that different design activities might require different working memory operators and reasoning processes based on the specific design goals [28]. While concept selection has been found to be an important component of creativity of the design process [29] that requires a different cognitive skillset that concept generation [27, 28], the relationship between empathic tendencies and concept selection has not been established.

This existing research provides conflicting interpretations on the role of empathy in design and the scarcity of research on the role of empathy in concept selection. Thus, formalizing the role of an individual's trait empathy in driving design outcomes in the concept generation and selection stages of the design process could bring great clarity to the existing research.

2.2 Measuring Trait Empathy

Trait empathy is "a social and emotional skill that helps us feel and understand the emotions, circumstances, intentions, thoughts, and needs of others such that we can offer sensitive, perceptive, and appropriate communication and support" [30]. Trait empathy can further be broken into a cognitive component and an affective component [31]. The cognitive component defines one's empathy as dependent on the situation, while the affective component characterizes one's empathy by the emotional response [31].

One of the widely used measures of trait empathy is Davis' Interpersonal Reactivity Index (IRI) [32]. The IRI defines trait empathy with four empathic tendencies: (1) perspective taking measures the ability "to adopt the perspectives of other people and see things from their point of view ([32]) pg. 12; (2) fantasy measures "the tendency to transpose themselves imaginatively into the feelings and actions of fictitious characters in books, movies, and plays" ([32], pg. 12); (3) empathic concern measures "the degree to which the respondent experiences feelings of warmth, compassion and concern for the observed individual" ([32], pg. 12); and (4) personal distress measures an "individual's own feelings of fear, apprehension and discomfort at witnessing the negative experiences of others" ([32], pg. 12).

While there are numerous methodologies for assessing trait empathy [32, 33], IRI is one of the few measures in the literature that encompasses both cognitive and affective components of empathy [31]. In engineering design, Hess and Fila [18] argue that both components are needed to allow designers to better understand the end-users' needs. While IRI has been used in prior work to assess the empathic tendencies of engineering students [34, 35], it has not been used in relation to creative concept generation and selection. Due to its rigorous development and acceptance in diverse communities of research, this study used IRI [32] to model designers' trait empathy and examine its relationship with driving designers' creative design outcomes.

3 Research Design and Methodology

In light of this prior work, the main goal of this study was to determine if or how engineering student trait empathy impacts their ability to generate and select creative concepts in a humanitarian engineering design project, see Fig. 1 for a summary of the factors investigated. Specifically, the following research questions (RQs) were devised:

1. *Can trait empathy be used to predict the number of ideas generated and the elegance, usefulness, and uniqueness of those ideas?* It was hypothesized that higher trait empathy would be related to the number of ideas generated and the elegance, usefulness, and uniqueness of those ideas due to prior work with engineering graduate students that found that trait empathy was related to innovative self-efficacy [34].
2. *Can trait empathy be used to predict the propensity for selecting elegant, useful, and unique ideas?* It was hypothesized that trait empathy would predict the propensity for selecting elegant, useful, and unique ideas due to prior work with engineering graduate students that found that trait empathy was related to their innovative self-efficacy [34].

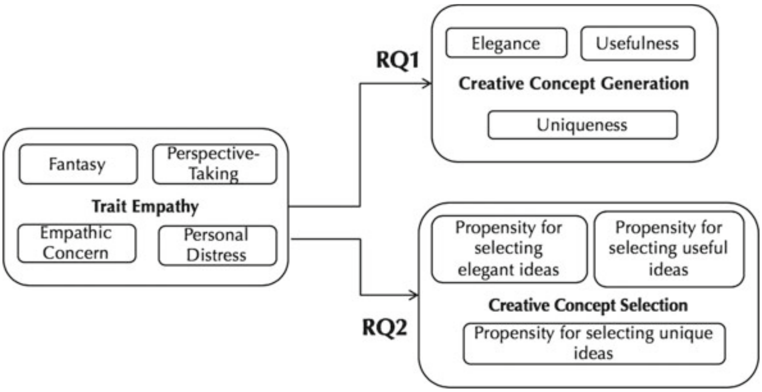

Fig. 1 Factors studied in the current investigation

The remainder of this section highlights the experimental procedure aimed at addressing those research questions.

4 Participants

Participants were recruited from four different classroom sections of a first-year undergraduate engineering design course at a large Northeastern university. In all, 103 first-year engineering students (73 men and 30 women) participated in the study.

5 Procedure

The study was completed over the course of an 8-week design project. Thus, the data presented here is part of a larger data collection effort geared at understanding the role of empathy in engineering design [36]. However, only the aspects of the study pertinent to the current investigation are described here, see Fig. 2.

At the start of the semester, the researchers presented the study to each of the four sections of the course according to the Institutional Review Board guidelines set forth at the university. Participation in the study was voluntary, and informed consent was gathered prior to the start of the study. Participants were then divided into 3–4 member design teams by the course instructor in their respective sections, and they were assigned the eight-week design project. The project focused on addressing the United Nation's Sustainable Development Goal 3 [37], which aims at "ensuring healthy lives and promoting well-being for all at all ages." Specifically, teams were asked to select between four different design challenges, see [38] for details on the problem statements. While participants in all four sections were allowed to select from these four design challenges, the design context of these challenges varied across the sections. Specifically, two of the sections focused on designing for the *developed* world (n = 50 participants) while the remaining two sections were tasked with designing for the *developing* world (n = 53 participants).

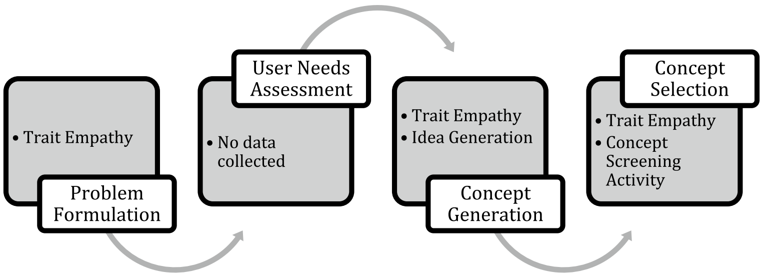

Fig. 2 Timeline of the project

After introducing the project, the participants completed a survey that included their demographics and trait empathy. The participants then continued to work on the project per the timeline presented in Fig. 1. Specifically, in weeks 1–2, the participants were asked to conduct user research, formulate a problem statement, and create an empathy map. Additionally, the participants were asked to generate a set of customer needs and conduct an external benchmarking activity in Weeks 3–4. During the concept generation stage (Week 4), participants were involved in two brainstorming sessions: reverse brainstorming [39], where they were given 15 min to *individually* brainstorm bad ideas that would make the problem worse, and then individual brainstorming where they were asked to *individually* generate concepts for 20 *min*. During the concept selection stage (Week 5), participants were asked to *individually* select concepts using a concept screening matrix. Finally, in weeks 6–8, participants were asked to prototype their solutions and report their final conceptual design. Of importance to the current study, participants were asked to complete the same Trait Empathy survey completed in week 1 of the study at the end of Week 4, immediately after the concept generation activity, and at the beginning of Week 5, immediately after the concept selection activity.

Three measures were taken in order to avoid experimental biases: throughout the eight-week project, we did not explicitly use the word empathy in the classroom instruction or in any of the survey materials; the survey that assesses participants' trait empathy was embedded with other surveys; and the surveys have not been labelled with the name of the scales [40].

6 Data Collection Instruments and Metrics

This section summarizes the metrics used to explore the factors critical to achieving the research objectives.

6.1 Trait Empathy

Participants' trait empathy was measured using the IRI, a 28-item survey answered on a 5-point Likert scale ranging from "does not describe me well" to "describes me very well". The IRI includes the following 4 subscales, each made up of 7 different items: perspective taking, fantasy, empathic concern, and personal distress. Due to previous research that shows that trait empathy changes between the design stages (problem formulation, concept generation, concept selection) [41], we have tested the hypotheses with participants' empathy at those different time points.

The four-factor structure of the IRI has been validated [42] and has been implemented to assess individuals' empathic tendencies [43, 44], including engineering students [34, 35]. A reliability analysis was conducted to evaluate the internal reliability of the subscales of the IRI, and a high Cronbach's α was observed [45] as 0.76 to 0.91 between all cases.

6.2 Number of Ideas Generated

The number of ideas was calculated for each participant by counting the number of idea sheets completed by each participant during the individual brainstorming session. This aligns with the quantity metric from the work of Shah, Vargas-Hernandez, and Smith [46].

6.3 Consensual Assessment Technique

In order to identify the effectiveness of the ideas generated, the Consensual Assessment Technique [47] (CAT) was used. CAT has been identified as a global measure of creativity [48] and has been widely used in prior research in the social sciences [49], education [50], and engineering design [51]. The method defines that an idea is creative when judges *independently* agree that it as creative [52]. The ideas were rated based on the following criteria: usefulness, uniqueness, and elegance using a six-point Likert Scale [53]. Specifically, (1) uniqueness relates to overall perceptions of how original and surprising the idea was [53], (2) usefulness relates to the overall perceptions of value, logic, and how understandable the ideas were, while (3) elegance refers to the idea's "simplicity, insight shown, and conciseness of [the idea's] presentation" ([53], pg. 288). Those metrics have been widely used in design research to assess ideation effectiveness in a design task [48, 54, 55]. In addition to the three metrics, experts' ratings of the overall creativity of the idea was collected; however, this aspect was a focus of a later investigation, and hence we did not include this analysis in the current paper.

The CAT utilizes experts to rate 20% of the complete idea set to provide a training set for quasi-experts to rate the remaining set based on the experts' mindset in rating the ideas [48]. Specifically, two faculty members experienced in engineering design research were recruited to independently rate 20% of the ideas. Additionally, two quasi-experts (PhD candidate and third-year undergraduate student, both studying Industrial Engineering) were recruited to independently rate the 20% overlap of ideas to ensure agreement with the expert judges [56]. The average of the quasi-experts' ratings had high agreement ($\alpha > 0.75$) [57] on each of the three metrics. Once inter-rater reliability was achieved, the two quasi-experts proceeded to rate the remaining 80% of the ideas independently and a high interrater reliability ($\alpha > 0.75$) [57] was achieved between the two quasi-expert raters for each of the three metrics. For each metric, an average of the scores from the two quasi-expert raters was calculated, as per recommendations by Silvia [58], see Figs. 3a and 3b for examples of CAT ratings.

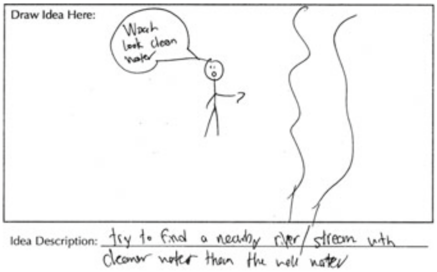

Fig. 3a An idea from participant 61 that received a score of 1 on usefulness, 1 on uniqueness and 1 on elegance

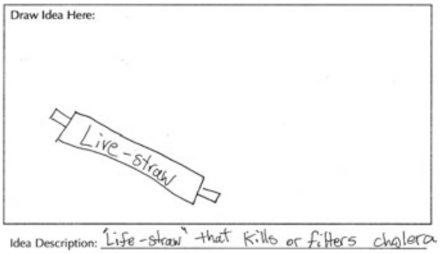

Fig. 3b An idea from participant 78 that received a score of 4 on usefulness, 4.5 on uniqueness and 5 on elegance

6.4 Propensity for Selecting Creative Ideas

To assess participants' propensity for selecting creative concepts, we used the propensity toward creative concept selection metric, P_C [23]. This metric was devised by Toh and Miller [23] and has been implemented in numerous design studies [24, 25]. In this metric, P_C measures the "…tendency towards selecting (or filtering) creative concepts during the concept selection process" ([23], pg. 118). For example, the formula to calculate participants' propensity towards selecting useful concepts ($P_{Usefulness}$) can be summarized as the following:

$$P_{Usefulness} = \frac{average\ usefulness\ of\ selected\ concepts}{average\ usefulness\ of\ generated\ concepts}$$

Similarly, participants' propensity towards concept selection of ideas rated high in (1) uniqueness and (2) elegance was also assessed in the same manner. An individual can receive a value ($P_{Usefulness}$) greater than 1 if the average usefulness of the selected ideas is higher than the average usefulness of the available ideas, indicating a propensity for selecting useful ideas. A value on $P_{Usefulness}$ that is less than 1 indicated a participant's aversion for selecting useful concepts [23]. Further details on the scoring methodology can be found in Toh and Miller's work [23].

7 Results

During the concept generation stage, participants developed a total of 806 ideas with an average of 8 ideas developed by each participant (SD = 3.53). In order to answer our research questions, statistical analyses were computed using SPSS 25.0, and a significance level of 0.05 was used in all analyses. The results are presented as mean ± standard deviation (SD), unless otherwise denoted.

Prior to addressing our research questions, we first needed to identify if the design context impacted students creative concept generation and selection [10, 17] to determine whether all teams could be treated as a single group or if context-dependent treatments were necessary. Specifically, a set of independent samples t-test were computed with the independent variable being the number of ideas generated by each participant, average usefulness of ideas generated, average uniqueness of ideas generated, average elegance of ideas generated, propensity for selecting useful ideas, propensity for selecting unique ideas, propensity for selecting elegant ideas, and the dependent variable being the context of the design problem (developing, developed). Prior to running this analysis, assumptions were checked. Due to finding outliers, the analyses were conducted both with and without the outliers to identify their influence on the results. The outliers were found to have no significant impact on the significance of the results and therefore, the full analysis (with outliers) is presented here. In addition, normality was confirmed; however, the Levine's Test for Equality of Variances revealed that the variety scores violated the assumption of homogeneity of variances, $p < 0.05$. Because of this, the Welch-Satterthwaite method was used to adjust the degrees of freedom [59].

The results of the *t*-test showed that the mean number of ideas produced by participants in developed world contexts (9.20 ± 4.050) was significantly higher than participants in developing world contexts (7.02 ± 2.454), a mean difference of 2.175 95% CI [0.845, 3.505], t (83.154) = -3.523, $p = 0.002$, Cohen's $d = 0.65$. These results indicated that participants working on developed world projects generated more ideas than participants working on developing world projects. However, participants' mean scores on usefulness, uniqueness and elegance were not significantly different between the two design contexts, $p > 0.05$, indicating that the design context did not impact the creativity of the ideas generated. Similarly, participants' propensity for selecting useful, unique and elegant ideas were not significantly different between the two design contexts, $p > 0.05$, indicating that the design context did not impact participants' propensity for selective creative ideas.

Based on these results, subsequent analyses that address RQ1 and RQ2 do not combine these two groups when analyzing the number of ideas generated by participants, but do combine these two groups for the remaining analyses.

RQ1: Can Trait Empathy be Used to Predict the Number of Ideas Generated and the Elegance, Usefulness, and Uniqueness of Those Ideas?

The first research question was devised to assess whether participants' trait empathy was related to *the number of ideas generated and the elegance, usefulness, and uniqueness of those ideas.* Based on prior work [34], it was hypothesized that higher trait empathy would be related to the number of ideas generated and the elegance, usefulness, and uniqueness of those ideas. Since we found that there were differences in the number of ideas between participants working on developing world sections compared to those working on developed world problems, separate statistical analyses were computed for participants in the two different design contexts.

First, in order understand the impact of trait empathy on the number of ideas generated by participants working on developing world projects, four multiple regression models were computed to predict number of ideas, from their empathic tendencies, perspective-taking, fantasy, empathic concern, and personal distress on the problem formulation and concept generation stages of the project respectively. This analysis was repeated for participants working on developed world projects.

Prior to the analysis, statistical assumptions were checked. The results showed linearity of the independent variables as assessed by partial regression plots and a plot of studentized residuals against the predicted values. There was also independence of residuals, as evaluated by a Durbin-Watson statistic of 1.910. By visual inspection of a plot of studentized residuals, the assumption of homoscedasticity was met. There was no multicollinearity in the independent variables, as assessed by tolerance values greater than 0.1. There were no studentized deleted residuals greater than ± 3 standard deviations, no leverage values greater than 0.2, and no values for Cook's distance above 1. Finally, normality was confirmed by visually inspecting the histograms and Q-Q plots.

For participants working on developing world problems, the results showed that the number of ideas can be significantly predicted from participants' trait empathy at concept generation, $p = 0.008$, $R^2 = 0.257$ (see Table 1 for summary for contributing predictors), but not for problem formulation, $p > 0.05$. Specifically, this finding found that empathic concern tendencies encouraged the generation of more ideas while perspective-taking and fantasy tendencies discouraged the generation of more ideas for participants working on developing world contexts. Meanwhile, for participants working on developed world problems, the results showed that the number of ideas cannot be significantly predicted from participants' trait empathy at problem formulation, $p > 0.05$, or concept generation, $p > 0.05$.

Second, in order to understand the impact of participants' trait empathy on their average scores on uniqueness, usefulness and elegance, 6 multiple regression models were computed to predict participants' average scores on uniqueness, usefulness and elegance, from their empathic tendencies, perspective taking, fantasy, empathic concern, and personal distress on problem generation and concept generation stages of the study respectively. While we found that there were differences in the number of ideas based on the design context, there were no differences based on participants' average usefulness, uniqueness, and elegance.

Table 1 Summary statistics of the regression model on the relationship between the number of ideas and trait empathy at problem formulation for participants working on developing world problems

Factor	B	*SE*	*β*	*p*
Perspective-taking	−0.324	0.136	−0.376	0.021*
Fantasy	0.012	0.102	0.017	0.906
Empathic concern	0.374	0.106	0.508	0.001*
Personal distress	−0.326	0.114	−0.420	0.007*

Note: B represents the unstandardized coefficient; SE represents the standard error associated with that coefficient; β is the standardized coefficient; *p* is the significance value associated with each factor

Therefore, separate models were not necessary. The results from the linear regression models did not significantly predict participants' usefulness, uniqueness and elegance from their four empathic tendencies at problem formulation, $p > 0.05$, or concept generation, $p > 0.05$, indicating that participants' empathic tendencies did not predict their creative concept generation.

These results partially support our hypothesis; the results showed that trait empathy in our sample predicted the number of ideas generated, but it did not predict the creativity of those ideas as measured through the CAT. Specifically, the results showed that for participants working in a developing world context, empathic concern predicted the generation of more ideas while perspective-taking and fantasy negatively predicted the generation of more ideas. This finding corroborates a qualitative investigation with engineering students [14] that found that empathic concern tendencies motivated students to work harder on an engineering task. On the other hand, the results indicated that personal distress and perspective-taking negatively predicted participants' number of ideas. This finding alludes to the discussion in the literature on the dark sides of empathy [20] (also known as the empathy trap [12]), where being empathic has been hypothesized to restrict a designer from coming up with creative innovations to a design problem [12].

RQ2: Can Trait Empathy be Used to Predict the Propensity for Selecting Elegant, Useful, and Unique Ideas?

While the first research question explored the relationship between participants' trait empathy and their creative concept generation, the second research question was devised to assess whether participants' trait empathy was related to their creative concept selection. Based on prior work [34], it was hypothesized that trait empathy would predict the propensity for selecting elegant, useful, and unique ideas. In order to understand the impact of participants' trait empathy on their propensity for selecting unique, useful, and elegant ideas, 9 multiple regression models were computed to predict participants' propensity for selection ideas that are rated high in usefulness, uniqueness, and elegance from their empathic tendencies, perspective taking, fantasy, empathic concern, and personal distress from problem formulation, concept generation, and concept selection. The results from the regression models did not significantly predict participants' propensity for selecting unique and elegant ideas from their four empathic tendencies at problem formulation, $p > 0.05$, concept generation, $p > 0.05$, or concept selection, $p > 0.05$. However, the results showed that participants' propensity for selecting useful ideas can be predicted from their trait empathy from problem formulation, $p = 0.026$, $R^2 = 0.118$ (see Table 2 for summary for contributing predictors), but not their trait empathy from concept generation, $p > 0.05$, or concept selection, $p > 0.05$. Specifically, the results indicated that personal distress positively predicted the selection of useful ideas while empathic concern negatively predicted the selection of useful ideas.

While empathic concern tendencies were helpful in encouraging designers to generate more ideas, empathic concern actually hindered designers' preference for highly useful ideas in the selection process. This dichotomy stands in support of

Table 2 Summary statistics of the regression model on the relationship between the propensity of selecting useful ideas & trait empathy from problem formulation

Factor	B	*SE*	*β*	*p*
Perspective-taking	−0.001	0.004	−0.376	0.889
Fantasy	0.004	0.003	0.017	0.181
Empathic concern	−0.009	0.004	0.508	0.022*
Personal distress	0.008	0.003	−0.420	0.024*

Note: B represents the unstandardized coefficient; SE represents the standard error associated with that coefficient; β is the standardized coefficient; *p* is the significance value associated with the factor

prior research [4, 25] that identified that the cognitive skills used in concept selection are very different from the skills used during concept generation. The results confirm prior work that discussed varying points of views [8, 9, 20] on the role of empathy in design, whereby we find evidence that supports the notion of the utility of empathy and the negative impact of empathy in the design process.

8 Discussion

The main goal of this paper was to identify the role of trait empathy in creative concept generation and selection in an engineering design student project. The first major finding from this study was that empathic concern tendencies positively predicted the generation of more ideas while perspective-taking and personal distress tendencies negatively predicted the generation of more ideas, for participants working on developing world projects. The second major finding was that personal distress tendencies positively predicted the selection of useful ideas while empathic concern tendencies negatively predicted the selection of useful ideas. These results are discussed in the following sections in relation to the research questions.

8.1 The Relationship Between Trait Empathy and Concept Generation

The first finding from the study indicated that trait empathy predicted the number of ideas generated by participants but not necessarily the creativity of those ideas. Specifically, for participants working on developing world contexts, empathic concern tendencies encouraged the generation of more ideas while perspective-taking and fantasy tendencies discouraged the generation of more ideas. These findings indicated that empathic concern, "the degree to which the respondent experiences feelings of warmth, compassion and concern for the observed individual" ([32], pg. 12), might be of more utility in terms of generating more ideas. This finding corroborates a qualitative investigation with engineering students [14] that found that empathic concern tendencies motivated students to work *harder* on an engineering task. This finding warrants future research that could empirically assess the relationship between trait empathy and designers' motivation.

On the other hand, the findings from our study indicated that personal distress and perspective-taking tendencies negatively predicted participants' number of ideas. This finding relates to findings in the literature that note how being empathic may restrict the designer from coming up with creative innovations to the existing problem [12]. This phenomenon is commonly referred to as *the dark side of empathy* [20] or *the empathy trap* [12].

8.2 The Relationship Between Trait Empathy and Concept Selection

While the first finding showed that the empathic concern encouraged designers to generate more ideas, the second finding from the study indicated that empathic concern discouraged the selection of ideas rated high in usefulness. Meanwhile, personal distress tendencies positively predicted participants' propensity for selecting useful ideas while it was not helpful in concept generation. This dichotomy resonates with prior research by Toh and Miller [4, 25] that identified that the cognitive skills used in concept selection are different from the skills used during concept generation.

Overall, the results from this study confirmed prior work that discussed varying points of views [8, 9, 20] on the role of empathy in engineering design, whereby we find evidence that supports the notion of the utility of empathy and the negative impact of empathy in both the concept generation and selection stages of the design process. Specifically, these results suggest that, while empathy may be useful throughout design, the utility of specific types of empathy vary depending upon the design stage. These findings confirm previous research [27] that found that different design activities might require different working memory operators and reasoning processes based on the specific design goals [28]. However, the results warrant future research that should assess the relationship of trait empathy with other design outcomes (e.g., the quality of the final design [46]).

8.3 Implications for Design Theory and Practice

The current literature is divided between discussing the positive [8, 9] and negative [12–14] impacts of empathy in design, in addition to being invested in devising empathy invoking interventions [8, 9]. This research adds to this body of knowledge by suggesting that, while empathy may be useful throughout design, the utility of specific types of empathy vary depending upon the design stage. In other words, the design community should be invested in preparing specific interventions to trigger specific types of empathic tendencies (e.g. perspective-taking, fantasy, empathic concern, or personal distress) depending on the design stage (e.g. concept generation, concept selection) and the desired outcome (e.g. useful, unique, or elegant ideas). Overall, this study took the first step towards our goal of encouraging empirical investigations aimed at understanding the role of trait empathy across different stages of the design process.

9 Conclusions and Future Work

The main goal of this study was to understand the role of trait empathy on creative concept generation and selection in an engineering design student project. The results from this research highlighted that empathic concern tendencies predicted the generation of more ideas while perspective-taking and fantasy tendencies negatively predicted the generation of more ideas. During concept selection, personal distress predicted participants' propensity for the selection of useful ideas while empathic concern negatively predicted the selection of useful ideas. The results from this research suggest that, while empathy may be useful throughout design, the utility of specific types of empathy vary depending upon the design stage.

However, there are several limitations that can lead to exciting avenues for future research. While this work began exploring the relationship between trait empathy and creative concept generation and selection, future research should assess the relationship of trait empathy with other design outcomes, such as the overall creativity of the ideas, or the quality of the final design. Moreover, while it is known that ideation patterns of first-year and senior-level students differ [60], this work only studied first-year students. Finally, while this research explored the utility of empathy in humanitarian engineering problems, future research is needed to extend these results with other engineering design tasks. Overall, the findings from this paper present some of the first evidence on the relationship between different components of trait empathy in driving creative design outcomes across the concept generation and selection stages of the design process.

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