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International contextual reliability of the Empathy and Care Questionnaire: the Australian context

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ABSTRACT

CONTEXT

Empathy has been identified as a key employability skill for professionals, underlying many skills and attributes anticipated as required by future engineers. The relevance and development of empathy and care as perceived by engineers has been quantitatively described in the USA and Germany using the Empathy and Care Questionnaire (ECQ). Cross—national variations in empathy have been reported outside of the engineering context.

PURPOSE OR GOAL

Building on research from the US and Germany, the aim of this paper is to confirm the transferability of the factor structure of the ECQ (Hess, Strobel, Pan, et al., 2017) in the Australian context. Given the influence of national culture on the development and experience of empathy, establishing contextual reliability of the ECQ is important to ensure conceptual consistency before conducting data analysis.

APPROACH OR METHODOLOGY/METHODS

This paper presents a confirmatory factor analysis (CFA) of the ECQ using data collected from engineers practicing in Australia. Engineers' perceptions of empathy and care within Australian engineering practice were collected using an online version of the ECQ (N = 183). A CFA was conducted to establish transferability of the item structure to the Australian context.

OUTCOMES

A marginal fit of the structure of Hess, Strobel, Pan, et al. (2017)'s five-factor model was indicated. Modification through incorporation of covariance errors improved the fit. These errors were observed to be associated with the wording of the items. The ECQ structure comprising of factors: i) *existence* of empathy and care within engineering work and practice, ii) *importance* of empathy and care within engineering practice, iii) potential *benefits* of a greater inclusion of empathy and care into engineering, iv) the value of empathy and care in *relational* aspects of engineering work, and v) the extent to which empathy and care are considered *learnable,* was found to transfer to the Australian context. Additionally, the factor relating to *learnability* of empathy and care exhibited comparatively lower internal consistency than other factors.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

The ECQ can be used with confidence in the structure transferring from the US context, for describing perceptions of empathy and care of engineers practicing in Australia. There are opportunities for further research to explore national context, and to enhance the structure and internal reliability of the instrument.

KEYWORDS

Empathy, care, engineering practice, survey, confirmatory factor analysis, cross-cultural validation

Introduction

Interpersonal qualities such as empathy and care have been identified as key employability skills for professionals, and necessary for sustained success in future work environments (Dondi et al., 2021). In the context of engineering, a socio-technical profession, empathy and care underpin many skills and attributes required by current and prospective engineers (Burnett et al., 2019).The understanding of empathy and care, their role within engineering practice, and the consideration of the development of empathetic and caring competencies are increasingly relevant for engineering education.

The conceptualisation and relevance of empathy and care in engineering practice, from the perspective of practicing engineers, is an emerging research area. In the North American context, practicing engineers perceive empathy and care as important to their roles as engineers, and to their engineering practice. Empathy and care are pertinent to relational aspects of engineering work, including effective communication and listening and respectful interactions, enabling meeting client and stakeholder needs, working in teams, and ethical and sustainable decision making (Hess, Strobel, Pan, et al., 2017; Pappa et al., 2020). Empathy and care impact engineering outcome quality. Empathic and caring orientations promote an other-centric focus and awareness of broader impacts of engineering decisions (Hess et al., 2016). Empathy is frequently associated with effective design through notions of user-centred design and empathic design approaches (Kouprie & Visser, 2009), which encourage an altruistic orientation to design and solution generation. While empathy and care are relevant to engineering practice and valued by engineers, the presence and practice of empathy and care in engineering workplaces was unclear until recently established in the US and German contexts using the Empathy and Care Questionnaire (ECQ) (Hess, Strobel, Pan, et al., 2017; Pappa et al., 2020).

Engineering students rank poorly on empathic dimensions in comparison to other student groups (Rasoal et al., 2012). However, empathy is considered to be a teachable skill (Walther et al., 2020) and the deficit presents an opportunity for engineering educators to foster empathy development in student engineers. Recent work by Walther et al. (2020), Hess, Strobel and Brightman (2017) and Harwood et al. (2020) explores the impact of varied pedagogical approaches and curricula elements on empathy development.

Empathy is frequently considered as an individual-level disposition, however cross-national variation in empathy has been established. Empathy is positively associated with collectivism (Duan et al., 2008), where collectivism reflects the tendency to place the needs of one's in-group above one's own needs (Hofstede, 2011). In a study of empathy across 63 countries, nations with collectivist values structures scored higher in empathic concern that individualist countries. While Western nations are frequently grouped together, marked differences were observed in their total empathy scores. Relevant to this paper, the US ranked 7th, Germany ranked 22nd, and Australia ranked 45th of 63 countries in total empathy score (Chopik et al., 2016). These differences suggest that engineers practicing in different national contexts may not perceive, experience, or prioritise empathy in the same way.

Duan et al. (2008, p. 58) note "because empathy is usually developed and experienced in a specific cultural context, neglecting the effects of cultural values may limit the accuracy and consistency of research findings into the nature and experience of empathy". Thus, in seeking to understand the perceptions and experiences of empathy and care within engineering, and in developing empathic and caring competencies in students, the consideration of national context is important.

The relevance and development of empathy and care in engineering in the Australian context has not been measured. In the overarching study we sought to assess the extent to which engineers' perceptions of the relevance and development of empathy and care extends from the US to Australia. As a part of this project, we measured the extent to which the structural characteristics of the ECQ extended form the US to the Australian context.

The Current Study

The paper presents a confirmatory factor analysis (CFA) of the ECQ (Hess, Strobel, Pan, et al., 2017) using data collected from engineers practicing in Australia. The aim of this paper is to confirm the factor structure of the ECQ in the Australian context. Given the influence of national culture on the development and experience of empathy, establishing contextual reliability of the ECQ instrument is important to ensure conceptual consistency before using the instrument for measurement in Australia.

Methodology

Empathy and Care Questionnaire (ECQ)

Engineers' perceptions of empathy and care within Australian engineering practice were collected using an online version of the ECQ (Hess, Strobel, Pan, et al., 2017). The ECQ was developed by Hess and colleagues from a synthesis of literature on empathy and care within engineering, and qualitative analysis of perceptions of empathy and care of engineering and non-engineering faculty.

The original instrument contained 37 items to investigate the existence, nature and importance of empathy and care within engineering practice. Items included 33 Likert-type scale items, and four 100-point items relating to respondents' perceptions of the general importance of empathy and care to them as individuals and as practicing engineers.

Hess, Strobel, Pan, et al. (2017) established a model structure of empathy and care through exploratory factor analysis (EFA). The model consisted of five factors, paired to 27 items:

1. The *existence* of empathy and care within engineering work and practice
2. The *importance* of empathy and care within engineering work, in general
3. The potential *benefits* of a greater inclusion of empathy and care into engineering
4. The value of empathy and care in *relational* aspects of engineering work
5. The extent to which empathy and care are considered *learnable*

Of the 37 items, the four 100-point items were excluded from the EFA due to differing scale. In addition, six items were excluded during derivation of the factor structure.

Online ECQ

An online version of the ECQ was created within the Qualitrics™ platform. The survey contained the 37 scale items of the original ECQ. In addition, three items related to engineers' perceptions of being treated with empathy and care by others at work, and one item expanded the investigation of the impact of empathy and care on attraction and retention of female engineers. The questionnaire also sought information relating to respondents' demographic and work-related characteristics, and provided opportunity for additional written comments.

Participants

The ECQ was disseminated to engineers between November 2019 and March 2021. Respondent recruitment was both purposeful and opportunistic, leveraging the researchers' professional networks. An invitation to participate with a link to the online questionnaire was distributed, consistent with ethics approval, by researchers and email by senior engineers in organisations and networks, and in engineering faculty alumni newsletters of two universities. Participation was voluntary and anonymous.

Respondents were 248 degree-qualified engineers who were practicing as engineers or working in related roles in Australia. These were reduced to 183 respondents (n_{male} = 125, 68.3% ; n_{female} = 58, 31.7%) for the CFA with removal of 59 responses due to insufficient questionnaire completion and three responses due to lack of demographic data.

Respondents were of median age range 40-44 years. They were well-distributed according to years of engineering work experience, with the largest proportion indicating that they had been working as engineers for under ten years (n = 57, 30.2%). Respondents were qualified and worked across a range of engineering disciplines. Respondents identified as electrical / electronics / communication engineers (n = 46, 24.3%), mechanical engineers (n = 41, 21.7%) and civil/structural engineers (n = 35. 18.5%) reflecting the historically available engineering disciplines. Of interest, 64 respondents indicated identifying with more than one engineering discipline, and 17.5% (n = 33) identified as multidisciplinary or interdisciplinary engineers. The dominant industry sectors were i) Professional, Scientific and Technical Services (79 of 290 responses); Mining (72 of 290 responses) and Electricity, Gas, Water and Waste Services (46 of 290 responses). The majority of respondents received their engineering qualification in Australia (n_{AUS} = 137, 72.5%; n_{INT} = 50, 26.5%; n_{NR} = 2, 1.0%;), and had spent most of their career working in Australia (n_{AUS} = 163, 86.2% ; n_{INT} = 25, 13.2%; n_{NR} = 1, 0.5%).

Data analysis

A CFA with maximum likelihood (ML) extraction and Cronbach's alphas were used to evaluate the internal structure of the empathy instrument, using LISREL V8.80 and IBM SPSS V26, respectively. The CFA included the 27 items included in the EFA of Hess, Strobel, Pan, et al. (2017). To ensure consistency, the four items added to the online version of the ECQ were not included in the CFA.

Given that preliminary screening analyses indicated significant skew in several variables, PRELIS normal scores were used in the analysis to enhance conformity of the distributions to the normality assumption. Polychoric correlations were used as the input data for the CFA. All other CFA assumptions associated with linearity, factorability, and the case-to-item ratio (6.96) were tenable. Outlier analyses indicated either one outlying value for seven of the items, and two outlying values for another two items. These values were removed from the analyses to ensure conformity to CFA assumptions.

Results

Three CFA models were conducted to evaluate the fit of the proposed structure to the data. The first model was based on the original five-factor structure described previously. In the second (unidimensional) model, all 27 items loaded on one factor. In the third, two conceptually related subscales (Perceived Importance and Perceived Benefits) were combined to determine whether the scores could be summarised by a smaller number of factors. The change in χ^2 among the models was used to evaluate whether the model fit statistics for the three models differed significantly. Fit indices for the three models tested are shown in Table 2.

Table 1 - Fit indices for three CFA models (*N* = 183)

Model	χ^2	***df***	χ^2/df	**NNFI**	**CFI**	**SRMR**
Original five-factor	1107.92	314	3.53	.85	.87	.10
One-factor	2657.92	324	8.20	.70	.73	.14
Four-factor	1487.74	318	4.67	.82	.84	.10
Modified five-factor	766.61	306	2.51	.90	.91	.09

Based on the $\Delta\chi^2$ statistics, the four-factor solution demonstrated superior fit to the one-factor model, $\Delta\chi^2(6) = 1170.18$, $p < .00001$. However, the original five-factor model demonstrated superior fit to both the one-factor and the four-factor alternative models, $\Delta\chi^2(10) = 1550.00$, p <

.00001, and $\Delta\chi^2(4) = 379.82$, $p < .00001$, respectively. Thus, based on these results, the original five-factor model was clearly the best-fitting.

However, the fit of the original five-factor model was somewhat marginal, using traditional cut-points for model fit from the literature. The ratio of the chi-square statistic to the model degrees of freedom (χ^2 / df), which measures the discrepancy between the sample and fitted covariance matrices, taking sample size into account was sound, with values ≤ 5 indicating acceptable model fit. The Non-Normed Fit Index (NNFI) and the Comparative Fit Index (CFI), however (both of which measure the relative fit of the proposed model to the null model, with the CFI being less sensitive to sample size than the NNFI), however, suggested some misfit to the data, with values ≥ .90 indicating acceptable model fit. Similarly, the Standardized Root Mean Square Residual (SRMR), which measures the difference between the residuals of the sample covariance matrix and the hypothesized model, fell just beyond the traditionally accepted cut-point of ≤ .08.

Therefore, while the original structure was the best fitting of the three tested, other indices did suggest some misfit between this model and the data. The modification indices obtained did, however, suggest eight large error covariances between items within the factors. An inspection of the items within each pair indicated that in all of these cases, the covariance could be attributed to similar item wordings (e.g., between CE4 and CE5, “My colleagues show empathy and care towards clients when s/he interacts with them”; “My colleagues show empathy and care when we work as a team”, and between CE7 and CE8, “I am aware of policies on empathy and care at my work”; “I am aware of policies on empathy and care in my profession”). Given that the addition of these covariances was deemed to be tenable, they were then incorporated into the model (Modified five-factor). As indicated in Table 2, the fit indices for this model now just met the cut-off levels for the NNFI and CFI, though the SRMR still fell just over the cut-off for this criterion. All five factors were significantly ($p < .05$) and positively correlated.

Moderate to high internal consistencies were also obtained for four of the subscales in the instrument, with αs of .86, .84, .83, and .82 for the Current Existence, Perceived Importance, Perceived Benefits, and Relational Value subscales, respectively. A somewhat lower value was obtained for the Learnability subscale of .66, which is attributable to the lower number of items within the subscale. In addition to the lower number of items for the latter subscale, as indicated by the coefficients for the paths between each of the items and their respective latent factors in Table 3, the path coefficients for two of the items in this factor were moderately low, which would further reduce the consistency of this particular subscale.

Table 2 - Path coefficients for five-factor model

Subscale	Coefficients (standard errors in parentheses)
Current Existence	CE1: 0.60(0.07); CE2: 0.75(0.07); CE3: 0.79(0.06); CE4: 0.65(0.07); CE5: 0.67 (0.07); CE6: 0.79(0.06); CE7: 0.63(0.07); CE8: 0.51(0.07)
Perceived Importance	PI1: 0.70(0.07); PI2: 0.61(0.07); PI3: 0.75(0.07); PI4: 0.69(0.07); PI5: 0.89(0.06)
Potential Benefits	PB1: 0.82(0.06); PB2: 0.69(0.07); PB3: 0.63(0.07); PB4:0.84(0.06); PB5: 0.84(0.06); PB6: 0.51(0.07)
Relational Value	RV1: 0.75(0.06); RV2: 0.53(0.07); RV3: 0.96(0.06); RV4: 0.88(0.06); RV5: 0.77(0.07)
Learnability	L1: 0.56(0.08); L2: 0.95(0.08); L3: 0.44(0.08)

Discussion

The results indicate some misfit between the original five-factor ECQ model structure established by EFA in the US context and the Australian data. Further investigation revealed eight large error covariances between items within the factors that may be attributed to similar item wordings. An improved model fit was achieved through incorporation of these covariances into the model, resulting in the modified five-factor model.

Our findings are similar to those of the CFA performed in the German engineering context (Pappa et al., 2020), where a marginal fit of the original five-factor model was indicated. In both contexts, the marginal fit of the model points to the presence of cross-national differences in perception, experience, or prioritisation of empathy and care (Duan et al., 2008) and indicates an opportunity for further development of the questionnaire for application in international contexts. ECQ items were developed through synthesis of literature, interviews with engineering and non-engineering faculty, and engineers practicing in the US context. Additional interviews or focus groups with practicing engineers in non-US contexts would provide a more expansive understanding of the nature of engineering work, engineering workplaces, and the relevance and impacts of empathy and care on their practice.

Pappa et al. (2020) associated the marginal model fit with a lower factor loading for the item *“I learned to be more empathetic and caring during my college years”* within the fifth factor: “the extent to which empathy and care are considered *learnable*”. An acceptable model fit was found following removal of this item. Our CFA also indicates a lower factor loading for items within this factor, with the lowest path coefficient associated with the same item: *“I learned to be more empathetic and caring during my college years*”. Examining the items within this factor, engineers in the Australian context who perceive that empathy and care are learnable, only partially associate learnability with universities and engineering workplace experiences. This indicates an opportunity for the improved development of empathetic and caring competencies during engineering studies and in engineering workplaces, and a need to build on the work of Walther et al. (2020), Hess, Strobel and Brightman (2017) and Harwood et al. (2020) in this area. Further examination of where and how engineers perceive empathy and care to be developed is also required for a deeper understanding of this factor.

Our findings suggests that while there is opportunity for further development, the five-factor model structure is transferable to the Australian context and thus contributes to confidence in using the ECQ to measure the existence, importance, benefits and learnability of empathy and care as perceived by practicing engineers in the Australian engineering context. Future work includes investigation of the perceptions of empathy and care by engineers in Australia, based on this model. Such analysis will enable a more expansive understanding of empathy and care within engineering practice, offering an increasingly contextual view of these concepts.

Conclusion

Our study builds on previous work that has indicated the existence and relevance of empathy and care to engineers and engineering practice (Hess, Strobel, & Brightman, 2017; Hess et al., 2016; Pappa et al., 2020), and the impetus for inclusion of these concepts into engineering education. A CFA of the ECQ developed within a US context indicates that the structural characteristics of the instrument can be extended to the Australian context. The CFA indicates the five-factor model is acceptable, with modification involving incorporation of covariance errors likely associated with wording effect. There are opportunities for further development of the instrument for improved transferability through: engagement with practicing engineers in non-US contexts through interview or focus groups to understand their workplace experiences, further exploration of the concept of learnability of empathy and care, and revision of the wording.

Outcomes of factor analysis in US, German and Australian contexts indicate that engineers do not strongly associate learnability of empathy and care with engineering studies or engineering workplace experiences. Given the centrality of empathy and care to effective engineering practice, there is an opportunity for Australian engineering educators to explore ways of strengthening empathetic and caring competencies during engineering formation.

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