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# An Initial Investigation of Funds of Knowledge for First-Generation and Continuing-Generation Engineering Students in Singapore


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**Abstract**

This initial study investigates the various sources of knowledge that may influence first-generation and continuing-generation college students in Singapore's engineering learning. College students' learning of engineering may be influenced by their families, communities, and work and school-related acquaintances sharing knowledge and skills. The purpose of this study is to determine how, and which sources of knowledge can assist a first-generation university student in adapting to the engineering course, seeking assistance from peers and those around them, and applying skills learned in the industrial aspect. This study employs a validated survey based on the ten latent constructs: tinkering knowledge from home and work, connecting experiences, networks from family members, college friends, colleagues, and neighborhood friends, perspective taking, reading people, and mediating capability. The survey also included the constructs of engineering performance and competence beliefs. A quantitative research method was then used to analyze the data. The study's findings aim to gain a more comprehensive understanding of how engineering students learn, allowing educators to use this knowledge to improve teaching methodologies and materials to provide better learning experiences for engineering students.


## Introduction

Funds of knowledge refer to the knowledge and skills gained by people in their home and community experiences. According to Greenberg (1989), Tapia (1991), and Velez-Ibanez (1988), the concept of "funds of knowledge" places great importance on strategic knowledge and associated activities that are significant in the way families function and develop their welfare. This information can be utilized to teach students more effectively (Vygotsky, 1990; Moll et al., 1992), and is especially pertinent for students who come from lower-income households, lack quality experiences, and lack access to the proper resources needed to improve their skills (Moll & Greenberg, 1990). Thus, learning about students' experiences allows researchers to understand how students adapt to their circumstances and continue to learn despite any obstacles encountered, and aids in making engineering education more equal and accessible to all groups of students (Moll et al., 1990).

Research has highlighted the significance of social networks and an individual's cultural and travel experiences in learning and teaching, which can shape their beliefs and provide them with a new perspective of the world, how they relate to things, and the things which they are passionate about (Moll et al., 1992). Thus, approaching learning and teaching from the funds of knowledge perspective helps develop participatory pedagogy, which provides students with greater latitude to analyze and employ creativity in generating ideas and solving issues (Moll et al., 1992). Moreover, the funds of knowledge perspective can be applied to engineering education in various manners. Engineering entails many different aspects, such as fixing, creating, and designing. It is possible that some interest in engineering could have stemmed from activities done, observed, or influenced by the family in the home setting (e.g., Bin Zulkifli & Yeter, 2022). Thus, experiences in the home setting can also impact one's view on engineering and how skills gained may be applied (Robinson et al., 2018).

This study aims to explore the various factors that may influence the learning of engineering for first-generation college students in Singapore. Such factors include families, communities, work, and school-related acquaintances sharing knowledge and skills. This involves studying students' social backgrounds, which may be indicative of the kinds of knowledge available in the households (Velez-lbanez & Greenberg, 1989). The research approach used in this study involves working on advancing our understanding of households and the nature of classrooms, working together with educators to conduct the research, and building new curriculums based on the understanding of how students think about and analyze information. This study ultimately aims to provide a better learning experience for students.

In this study, engineering students from different faculties at one university in Singapore were surveyed. Subsequently, the data collected from first-generation college students were compared with that of continuing-generation college students, to identify any differences. To date, such a study has not been conducted in Singapore.

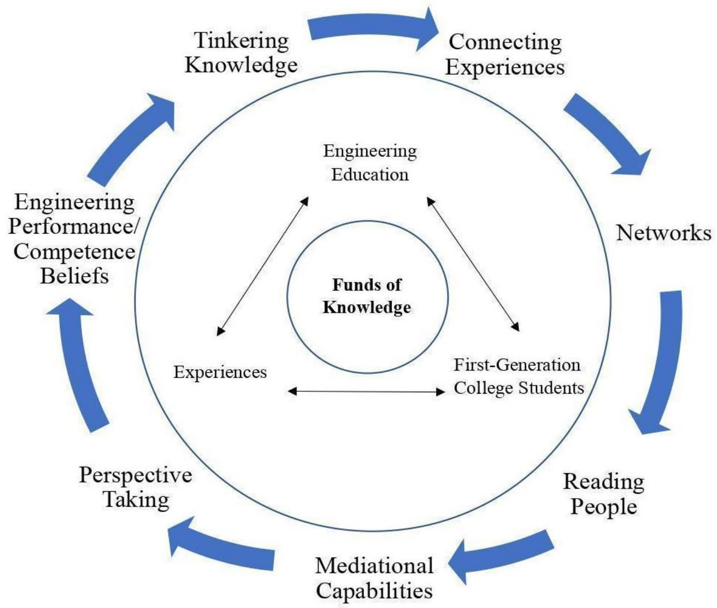
## Theoretical Framework

Engineering needs to be taught in a diversity of contexts applicable to real life. When students are able to see how the material, they are learning is applicable and relevant to real-world contexts, there is a greater likelihood that they will have a greater incentive to engage in learning (Yeter et al., 2016). However, engineering activities are often set in engineering contexts that do not appeal to underrepresented minorities and thus fail to engage students' interests and attention. For instance, engineering is often seen as a male-dominated field that is only for "smart" people, which makes it pertinent to dismantle this stereotype and focus on improving inclusivity in the field of engineering to show all students that they can be engineers, regardless of their gender, race, or any other demographic feature (Lachapelle et al., 2014).

Currently, the teaching and learning of engineering seem to follow a fixed narrative that does not allow room for creativity and different perspectives, making it disadvantageous to students from different backgrounds. Engineering is a subject that requires a lot of support from family, friends, and the community, an aspect usually overlooked or completely neglected in curriculum planning (e.g., Van den Bogaard et al., 2021). As students come from diverse backgrounds, they will each have different experiences or resources. Naturally, students who receive less motivation from their families and may not have as much access to quality resources may perform worse. A possible reason for this is that students with less access to tools and quality experience must work harder to motivate themselves as they learn everything from scratch, by themselves, whereas those from more advantaged backgrounds may already possess some fundamental knowledge, as well as the means to seek help when needed.

Thus, funds of knowledge found in support networks, which comprise family units, communities, and other places, are important in the transfer of knowledge, support, and other information to engineering students. The funds of knowledge perspective differ from traditional approaches in engineering education, in that it allows one to use experiences, networks, and relationships as sources of knowledge to better understand students and their backgrounds, and consequently teach them in a more effective manner (Moll et al., 1992). This allows for a more flexible teaching style in which students are not limited to following a specific method but are given greater liberty to approach problems in different ways to yield the same result (Moll et al., 1992).

**Figure 1.** *Model illustrating how the constructs of funds of knowledge and engineering education are related*




As illustrated in the figure 1, there are 10 latent constructs that constitute the funds of knowledge instrument to be assessed: (1) tinkering knowledge from home, (2) tinkering knowledge from work, (3) connecting experiences, (4) networks from family members, (5) networks from college friends, (6) networks from colleagues, (7) networks from neighborhood friends, (8) perspective taking, (9) reading people, and (10) mediating capability (Verdin et al., 2021). An additional construct is included in the instrument to assess students' engineering performance and competence beliefs (Verdin et al., 2021). Created using ethnographic and interview data, the 10 constructs place a clear focus on social exchanges, cultural and familial impacts on individuals (Verdin et al., 2021), and an individual's personal beliefs about their self-efficacy in engineering (Verdin et al., 2021). Social exchanges are salient as they can impact how an individual learns and subsequently applies the material taught. For instance, researchers such as Vygotsky (1980) and Wenger (2010) have found that tinkering enables social learning and encourages teamwork, where those participating can create goals that are meaningful to the community, they are from by using various tools related to mediation (Poce et al., 2019).

Different students will inevitably be from different backgrounds, and thus possess different resources and experiences that can be converted into skills and knowledge that can add value to their learning (Bourdieu, 1986; Coleman, 1988; and Putnam, 1993). The 10 latent constructs may also explain why and how a first-year engineering college student chooses the course, what motivates them to stay in the course, and how they succeed in the course (Verdin et al., 2021). Another pertinent construct, especially for women and students from minority groups, is that of connecting experiences (Strayhorn, 2018). As connectedness encourages persistence, this construct is relevant to students who may be marginalized and face more obstacles in the field of engineering. Additionally, it is important to be mindful of the influence of cultural and familial impact as different cultures may have different practices and ideologies. These aspects may affect students' mindsets and the way they view situations, providing every individual with a unique approach to situations (Verdin et al., 2021). Therefore, the 10 latent constructs are employed to gain a better understanding of students from different backgrounds and to eventually provide an improved method of teaching engineering.

## Purpose of the Study

As this study was conducted in Singapore, the location and demographics of the study differed greatly from previous studies on the same topic, which were generally held in the United States of America. Singapore is a diverse, multicultural society. Hence, one can expect a range of different experiences from different people and groups and, thus, a large variety of methods that were learned. Many Singaporeans are not encouraged or motivated to pursue an engineering or science major as they may believe other career options offer better job prospects. They may also believe they are not intelligent enough to pursue education in science-related fields (Begum, 2019). Moreover, their parents may insinuate that having a science or mathematics background may not be useful in the future, spurring them to pursue careers in other fields (Begum, 2019).

A salient problem in the engineering education curriculum in Singapore is that it focuses more on academic progress and technical teaching as opposed to adopting a more holistic approach that allows creativity (Pee & Leong, 2006). Students face intense academic pressure to perform well in exams, which may inhibit them from actually learning engineering processes, as they may be more focused on memorizing information to achieve good exam scores. This may result in students being unable to apply the learned material in the future (Tan, 2021). Research has shown that failure can be used as a learning tool in STEM education, which can motivate students to find solutions (Svitak, 2014; Burley et al., 2016a, 2016b; Youngblood et al., 2016). However, such a positive outlook on failure is incompatible with the current results-oriented education system that heavily condemns failure.

Furthermore, the current engineering education curriculum may not adequately equip students with the necessary skills to face the ever-changing nature of the 21st century (Pee & Leong, 2006). Currently, the workforce demands individuals possess multidisciplinary knowledge and both hard and soft skills, such as communication (Tan, 2021). Thus, the usual methods of teaching and learning may be inadequate to properly equip students with the skills needed in the workforce. Students must instead embrace a new form of learning in which they gain knowledge and learn to apply information and concepts from different perspectives (Tan, 2021). Consequently, Telenko et al. (2015), Kazerounian & Foley (2007), and Klukken, Parsons, & Columbus (1997) have found that this new form of learning requires a curriculum that applies problem-focused, project-based, and design-centric education. As of late, much emphasis has been placed on the need to develop a curriculum that is more open-minded instead of one that employs activities that have a fixed narrative (Tan, 2021). Therefore, this study aims to address the wider community of people who are studying engineering in Singapore as first-generation college students to address the different challenges and experiences they have had in order to better understand and develop a better method to teach engineering.

## Research Questions

This study focuses on the following two research questions; (1) What are the psychometric properties of the instrument employed in terms of reliability and correlation among the latent factors in the context of Singapore? And (2) is there any significant difference between subgroups (e.g., genders, first-generation vs continuing-generation college students) with respect to the seven latent factors of the instrument employed?

## Methodology

### Instrument

The instrument measured six of the 10 latent constructs developed in Verdin's study (2021): (1) tinkering knowledge, (2) connecting experience, (3) networks from family members, college friends, colleagues, and neighborhood friends, (4) perspective taking, (5) mediating capability, and (6) reading people. The instrument also included the construct of engineering performance/competence beliefs to understand students' abilities. A visual model (Figure 1) was constructed to represent the interactions between each construct.

### Data Collection

A survey was administered to first-generation and continuing-generation engineering undergraduate students from a higher education institution in Singapore in 2022, which provided the data for this study. A focused and related sampling method was employed to gain a more representative sample, particularly to include more students who identified as low-income and/or first-generation university students. To gain a more comprehensive understanding of the funds of knowledge possessed by first-generation college students, data from both first-generation and continuing-generation students was collected and compared. The demographics of the sample (N = 46) are detailed in Table 1.

Table 1. *Demographics of Survey Participants*

| **Category** | **Sub-category** | **Frequency (N)** | **Percent (%)** |
|---|---|---|---|
| Gender | Female | 15 | 32.6 |
| | Male | 30 | 65.2 |
| | Rather not say | 1 | 2.2 |
| Race | Burmese | 1 | 2.2 |
| | Caucasian | 1 | 2.2 |
| | Chinese | 38 | 82.6 |
| | Indian | 2 | 4.3 |
| | Malay | 4 | 8.7 |
| Grade level | 1st (Freshman) | 3 | 6.5 |
| | 2nd (Sophomore) | 4 | 8.7 |
| | 3rd (Junior) | 32 | 69.6 |
| | 4th (Senior) | 7 | 15.2 |
| Generation | First-Gen | 22 | 52.2 |
| | Continuing-Gen | 24 | 47.8 |

The survey instrument was administered through the use of Google Forms, an online survey platform. All participants were ensured that their answers would be confidential and that their participation in the survey was based on their own volition. The data collected was then exported from Google Forms to an Excel file, which was then moved to the SPSS 28 program for data analysis.

**Data Analysis**

In the data analysis of this study, the skewness and Kurtosis coefficients were obtained for each item. Additionally, we examined the internal reliability of the seven constructs separately through Cronbach’s alpha. Furthermore, Pearson’s correlation analysis was conducted to examine the convergence of the seven constructs. To conduct the correlation analysis, aggregate-level items were created per construct, yielding seven variables: tinkering, networks, connecting experiences, perspective-taking, reading people, mediating capability, and engineering performance/competence beliefs.

To compare the two variables of students' college generation (first-generation college students and continuing-generation college students) and gender (female and male), we ran a series of Mann-Whitney U tests in SPSS (v28). The Mann-Whitney U test, a nonparametric test, was chosen, considering the small sample size of this study, despite some variables meeting the normality condition. Additionally, compared to other parametric tests, such as the independent sample t-test, the Mann-Whitney U test produces more conservative results, which are more likely to be accurate.

## Results

To answer research question 1, as shown in Table 2, the instrument had high reliability and internal consistency, as indicated by the high Cronbach alpha scores of each of the seven constructs utilized in the instrument: tinkering ($\alpha$ = .767), networks ($\alpha$ = .866), connecting experiences ($\alpha$ =.843), perspective taking ($\alpha$ = .826), reading people ($\alpha$ = .939), mediating capability ($\alpha$ = .918), and engineering performance/competence beliefs ($\alpha$ = .797).

Table 2. *Summary of Cronbach's Alpha Results for each Construct*

| Constructs | Cronbach's alpha |
|---|---|
| Tinkering (N = 8) | .767 |
| Networks (N = 12) | .866 |
| Connecting experiences (N = 4) | .843 |
| Perspective taking (N = 6) | .826 |
| Reading people (N = 5) | .939 |
| Mediating capability (N = 5) | .918 |
| Engineering performance/ competence beliefs (N = 4) | .797 |

Additionally, as seen in Table 3, from Pearson's correlation analysis, some constructs had positive correlations while others had negative correlations. There was a significant negative correlation between tinkering and connecting experiences, r (45) =.373, p =.011. There were also significant positive correlations between connecting experiences and networks, r (45) =.345, p=.019; perspective taking and networks, r (45) =.392, p=.009; reading people and perspective taking, r (45) =.401, p=.006; mediating capability and perspective taking, r (45) =.423, p=.003; and mediating capability and reading people, r (45) =.400, p=.006. Additionally, there were significant positive correlations between engineering performance/ competence beliefs and networks, r (45) =.366, p=.012; as well as with connecting experiences, r (45) =.392, p=.007.

To answer research question 2, as seen in Table 4, there were no statistically significant differences between first-generation and continuing-generation college students across all seven constructs. continuing-generation college students scored higher than first-generation college students on four of the seven constructs used. Notably, on average, first-generation college students scored higher on the construct of tinkering (M = 3.84, SD = 1.01), perspective taking (M = 5.18, SD =.790), and reading people (M = 3.79, SD = 1.42) compared to continuing-generation college students, who had mean scores of 3.35 (SD = 1.30), 4.99 (SD =.841), and 3.48 (SD = 1.33).

From Table 5 (in Appendix A), we observed that there were no statistically significant differences between male and female students across all seven constructs. For four out of the seven constructs used, male students had higher average scores compared to female students. However, female students had higher average scores for networks (M = 3.20, SD = 1.05), connecting experiences (M = 2.93, SD = 1.46), and reading people (M = 3.76, SD = 1.50) compared to male students, who had mean scores of 2.50 (SD = 1.21), 2.82 (SD = 1.81), and 3.57 (SD = 1.35), respectively.

As seen in Table 6 (in Appendix A), no significant difference was found between lower-level college students (i.e., Year 1 and Year 2 students) and upper-level college students (i.e., Year 3 and Year 4 students), as seen in Table 6. Lower-level college students had higher average scores for five of the seven constructs examined. Upper-level college students only had higher average scores for reading people (M = 3.64, SD = 1.33) and mediating capability (M = =3.96, SD =1.42), compared to lower-level college students, who had means of 3.60 (SD = =1.67) and 3.89 (SD =1.22), respectively.

In summary, the data analysis revealed that the instrument had high internal validity, confirming the validity of the funds of knowledge survey instrument used by Verdin et al. (2021). Additionally, from the correlation analysis, we concluded that while some constructs had positive correlations, others had negative correlations. The data analysis also revealed no significant statistical differences were found between students' college generation, gender, or level of education in the seven constructs used in the instrument. It must be noted that the small sample size of this study (N = 46) was likely the cause of the lack of statistical significance for various statistical relationships examined. As such, future studies should involve a larger number of participants to verify the results of this study.

First-generation college students have a multitude of experiences that allow them to possess a vast pool of knowledge, skills, and methods. This study has only managed to capture a fraction of the experiences, knowledge, skills, and methods students have acquired. Additionally, as this study only used data collected from one university in Singapore, the results may not be reflective of the overall demographics of the population.

Table 3. *Summary of Data Analysis Results of Correlation Between Different Constructs*

| **Constructs** | **Tinkering** | **Networks** | **Connecting experiences** | **Perspective taking** | **Reading people** | **Mediating capability** |
|---|---|---|---|---|---|---|
| Tinkering | - | | | | | |
| Networks | 0.189 | - | | | | |
| Connecting experiences | .373* | .345* | - | | | |
| Perspective taking | -0.003 | .392** | 0.281 | - | | |
| Reading people | -0.1 | 0.172 | 0.208 | .401** | - | |
| Mediating capability | 0.084 | 0.283 | 0.12 | .423** | .400** | - |
| Engineering performance/competence beliefs | 0.166 | .366* | .392** | 0.228 | -0.086 | 0.063 |

*Note:* *Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

Table 4. *Summary of Data Analysis Results Between First-Generation and Continuing-Generation College Engineering Students*

| **Constructs** | **G1 Mean (SD)** | **G2 Mean (SD)** | **Skewness G1 / G2** | **Kurtosis G1 / G2** | **Mann-Whitney U (asymptotic *p* value, two-tailed)** |
|---|---|---|---|---|---|
| Tinkering (N = 8) | 3.84 (1.01) | 3.35 (1.30) | -0.31/-.209 | .720/-.163 | 205.000 ($p = .193$) |
| Networks (N = 12) | 2.70 (1.20) | 2.72 (1.19) | -.639/.018 | .288/-.420 | 250.500 ($p = .766$) |
| Connecting experiences (N = 4) | 2.81 (1.79) | 2.96 (1.60) | -.280/-.295 | -1.03/-.985 | 251.500 ($p = .783$) |
| Perspective taking (N = 6) | 5.18 (.790) | 4.99 (.841) | -1.17/-1.012 | .331/1.85 | 226.000 ($p = .401$) |
| Reading people (N = 5) | 3.79 (1.42) | 3.48 (1.33) | -.417/-.429 | -.267-.133 | 228.000 ($p = .428$) |
| Mediating capability (N = 5) | 3.82 (1.57) | 4.08 (1.19) | -.535/-.960 | -.369/.298 | 239.000 ($p = .582$) |
| Engineering performance/competence beliefs (N = 4) | 3.43 (1.01) | 3.69 (1.36) | -.180/-.127 | .274/-.609 | 238.000 ($p = .566$) |

*Note:* G1 refers to first-generation college engineering students. G2 refers to continuing-generation college engineering students

**Conclusion**

This study aims to address the gaps in engineering education in Singapore, particularly for first-generation college students. Compared with the data of first-generation university students with that of continuing-generation university students, we can observe some key differences between the funds of knowledge of each group. Understanding the knowledge, skills, and resources each group possesses allows educators to design a more effective and inclusive engineering curriculum that considers the different backgrounds students come from, and that not all students have equal access to the same knowledge, skills, and resources. Instead of expecting all students to be of the same background, and have access to all the same resources, engineering education can draw from the funds of knowledge perspective and be revised to be more equitable and inclusive towards students of different backgrounds.

The findings from this study also provide empirical evidence to support a change in the K-12 curriculum in Singapore. A student's motivation to pursue an engineering course, as well as the experiences gained by a student from their home, school, neighborhood, and work, can be shaped by their K-12 education. Integrating engineering education into K-12 education in Singapore allows students to be exposed to the field of engineering from a younger age. The benefit of this is twofold: firstly, students can gain a better understanding of engineering, how it is applied in the real world, and why it is important. Secondly, students can gain greater confidence in their engineering skills and knowledge, regardless of their background.

As many students at the pre-university level in Singapore may feel that engineering is not important or that they are not intelligent enough, a better understanding of engineering's importance and increased confidence in one's engineering skills and knowledge could eventually encourage students to consider engineering as a potential career path. Additionally, integrating engineering education into the K-12 curriculum would allow for a more seamless transition between studying engineering at the K-12 level and at the undergraduate level. Furthermore, Yeter et al.'s study (2022) reveals that engineering indices are already present across the pre-college physics curriculum in Singapore. The study also identifies entry points to introduce engineering education into the curriculum and integrate engineering practices into existing physics curricula. This could introduce engineering practices to students from a younger age, and eventually motivate students to pursue STEM-related fields.

Tinkering knowledge from home, perspective-taking, and peers from school can significantly influence engineering education, and thus, K-12 curricula could be redesigned to integrate these factors and ensure more effective teaching and learning. For example, to integrate tinkering with knowledge from home into school curricula, practical lessons can be held in class to allow students to experiment with projects that enable them to create or tinker with home-related objects. Educators can then show students how the projects can be applied in an engineering context, helping students make the connection between the tinkering activity and engineering. Similarly, for perspective-taking, students can be taught to apply empathy and ethical practices in their engineering projects by taking into consideration the needs of different stakeholders involved in the engineering project. Future research could study the effects of implementing engineering education in K-12 curriculum can affect the funds of knowledge of first-generation college students, as well as how such an engineering curriculum affects students’ academic performances and mindsets.

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**Appendix A:** Data Analysis Results

Table 5. *Summary of Data Analysis Results Between Male and Female College Students*

| **Constructs** | **Female Mean (SD)** | **Male Mean (SD)** | **Skewness Female/Male** | **Kurtosis Female/Male** | **Mann-Whitney U (asymptotic *p* value, two-tailed)** |
|---|---|---|---|---|---|
| Tinkering (N=8) | 3.39 (.923) | 3.67 (1.31) | .288/-.494 | .025/.153 | 182.500 ($p$ = .305) |
| Networks (N=12) | 3.20 (1.05) | 2.50 (1.21) | -1.24/.012 | 1.527/.184 | 122.000 ($p$ = .013) |
| Connecting experiences (N=4) | 2.93 (1.46) | 2.82 (1.81) | -.306/-.219 | -0.562/-1.174 | 217.500 ($p$ = .856) |
| Perspective taking (N=6) | 4.91 (.900) | 5.18 (.777) | -.388/-1.58 | -1.204/3.542 | 186.000 ($p$ = .345) |
| Reading people (N=5) | 3.76 (1.50) | 3.57 (1.35) | -.301/-.495 | -.506/-.155 | 202.500 ($p$ = .587) |
| Mediating capability (N=5) | 3.95 (1.46) | 4.00 (1.36) | -.749/-.873 | -.13/.436 | 224.000 ($p$ = .981) |
| Engineering performance/competence beliefs (N=4) | 3.42 (1.27) | 3.66 (1.19) | -.109/-.038 | .209/-.463 | 200.000 ($p$ = .546) |

Table 6. *Summary of Data Analysis Results Between Lower-Level and Upper-Level College Students*

| **Constructs** | **LL Mean (SD)** | **UL Mean (SD)** | **Skewness LL/UL** | **Kurtosis LL/UL** | **Mann-Whitney U (asymptotic *p* value, two-tailed)** |
|---|---|---|---|---|---|
| Tinkering (N=8) | 3.80(.863) | 3.54 (1.23) | -1.79/-.180 | 4.22/.082 | 102.500 (p = .297) |
| Networks (N=12) | 2.92(.861) | 2.68(1.24) | -.065/-.245 | -1.97/-.304 | 126.500 (p = .760) |
| Connecting experiences (N=4) | 3.64(1.80) | 2.75(1.64) | -1.81/-.123 | 2.81/-.910 | 91.500 (p = .168) |
| Perspective taking (N=6) | 5.55(.448) | 5.00(.839) | -1.43/-.907 | 2.22/.647 | 83.500 (p = .103) |
| Reading people (N=5) | 3.60(1.67) | 3.64(1.33) | .463/-.590 | -.873/-.062 | 125.000 (p = .725) |
| Mediating capability (N=5) | 3.89(1.22) | 3.96(1.42) | .722/-.870 | .120/.004 | 115.500 (p = .520) |
| Engineering performance/competence beliefs (N=4) | 4.07(1.20) | 3.47(1.19) | .622/-.115 | -1.13/-.345 | 106.000 (p = .349) |

*Note*: LL refers to lower-level college students (i.e., Year 1 and Year 2 students). UL refers to upper-level college students (i.e., Year 3 and Year 4 students).