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Innovation Level Amongst Engineering And Non-Engineering Undergraduate Students In One Of The University In Malaysia

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Abstract.
Engineers of the future must be capable of working successfully in multidisciplinary teams. Consequently, to advance innovative endeavours, engineering education and training should be considered in economic policies. The purpose of this study was to determine the significance of differences in innovation capabilities between engineering and non-engineering students. The research design is quantitative, using a questionnaire as the research instrument. The population were undergraduate students at a Malaysian university. Only 223 out of 370 respondents provided feedback within two weeks of data collection. 117 were non-engineering students, and the other 106 were engineering students. To measure the differences between the two groups of students, an inferential t-test was used. The Rasch analysis approach was applied to analyse the profiles of the students. The results showed that the innovation level of engineering students was greater than that of non-engineering students. Non-engineering students demonstrate marginally more (n=105, 47.09%) than engineering students (n=99, 44.39%) in "Very High Levels" of innovation. As a result, engineering education has grown and increased demand to efficiently train a diverse group of engineers for these challenges.

Keywords: innovation; independent sample t test; engineering students;non-engineering students; Rasch analysis; profile

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1. Introduction

Engineers of the future must be capable of working successfully in multidisciplinary teams. As a result, universities should take the lead in expanding their engineering design curriculum in response to this challenge. This is because industry requires engineers who have prior experience working with other fields; innovation is often ignited by the intersection of several disciplines (Manzini, 2015).

In fact, the National Academy of Engineering 2015 reported in Educating the Engineer of 2020 that the encouragement was to educate engineers who are "technically qualified and innovative". Engineers make important contributions to society, resulting in innovations in almost every aspect of everyday life (Ferguson et al., 2017). Innovation is critical in generating new opportunities for society's social and economic growth too. It is a deliberate process that entails the application of knowledge, creativity, and effort to turn an idea or innovation into tangible products or services. As a result, engineering education and training are critical economic policies for contributing to innovative initiatives. In fact, innovation is a critical part of a comprehensive development agenda because it increases efficiency and prosperity in the pursuit of inclusive development.

Nevertheless, several studies have been performed previously on innovation in the context of engineering students by (Ferguson et al., 2017; Law & Breznik, 2017; Oehlberg et al., 2012; Passig & Cohen, 2014; Schar et al., 2017), but they covered a wide range of topics. Overall, this study contributes to the development of an instrument to measure students' innovation level in one of Malaysia's higher education institutions. However, this article focusing the findings of the study on differences of innovation level based on innovation constructs between engineering and non-engineering students as well as their profiling. The survey was administered by cluster random sampling.

2. Literature Review

There was a huge variety of opinions by scholars on the definition of innovation. Moreover, the idea of innovation depends mainly on its application. However, the term "innovation" has been defined broadly in the literature and has been combined with creativity (Ferguson Daniel & Ohland Matthew, 2011). Based on previous studies, there are several definitions of innovation, and most Malaysian imitates the innovation term with creating something new.

Regarding to traditional source, Oxford Dictionary defined innovation as "make changes in something established, especially by introducing new methods, ideas, or products". Van der Panne et al. (2003) also defined innovation as a process of developing and implementing a new idea . Similarly, innovation is concerned with novel concepts, experiments, and processes (Kanter, 1984; Urabe, 1988; West, 2002). Innovation is a novel concept that can be applied in a variety of ways Innovation results in enhancements and adaptations to existing thought and ideas in order to provide added value that can be used and employed, as well as sold as a product or service (Zaini, 2010). The definition of general innovation consists of a variety of definitions for multi-disciplinary concepts.

There is much dispute among engineering educators and practitioners, as well as in general culture, over the definition of the term 'innovation.' Ferguson et al. (2017) elaborated the innovation definition in engineering by the outputs of performance aspects (i.e., the 'what'), such as patents, new products, increased sales, and/or cost savings, rather than the expertise, skills, or characteristics of the engineers who generate those outputs. Thus, to fill the gap in this study, the researcher discovered a dearth of academic research on the characteristics of innovation acquired by engineers in meeting potential industry and national challenges and opportunities. Countless professionals such as entrepreneurs, artists, designers and engineers –have been classified as innovators; nevertheless, despite the presence of several generic innovativeness competency models and domain-specific competency definitions (Menold et al., 2016; Mulder, 2014; Zlatkin-Troitschanskaia et al., 2017) , no consensus concept of the characteristics of an innovative engineer has been developed.

Ferguson et al. (2017) showed that while numerous research have been published on innovators, the majority are not engineering-specific. To fill the research gap, they conducted in-depth interviews with leading engineering innovators to discover engineers' viewpoints on innovation and the characteristics of engineers who invent, develop, and implement innovations. Thus, in this study, it is necessary to examine the relationship between engineering and innovativeness characteristics. Additionally, the study's objectives are reinforced when Law and Breznik (2017) discovered that engineering students' innovativeness is significantly and strongly associated with self-efficacy and significantly with attitude. Yet, engineering students' attitudes are found to be more important in determining their entrepreneurial goal specifically. Besides, Passig and Cohen (2014) developed and validate a tool; Ideas Generation Implementation (IGI) to measure the innovative thinking among engineering students from Israeli universities. Three factors relating to creative styles were assessed in 145 engineering undergraduate students: efficient, conformist and original. In summary, innovation is necessary on a different levels and for a variety of reasons.

Generally, definition of innovative address a broad range by many researchers based on their scopes of study. Based on preceding literature conducted by Abdullah et al. (2016) innovative individual generally has been conceptualized by characteristics, traits and behavior variables. For instance, individual innovativeness were measure based on willingness to change (Hurt et al., 1977; Sommer et al., 2017), measure of role innovation on how many changes has initiated in employers (Kessler et al., 2015; West, 1987), measure innovative behavior based on product creativeness (Amabile, 1988). Thus, innovative behavior can be construed in many measures and elements.

Thus, based on literature review and meta data analysis, innovative students in this study refers to students who have Human Capital (Dakhli & De Clercq, 2004; Fonseca et al., 2019; Sullivan & Sheffrin), Culture (Ahmad & Abdullah, 2015; Dobni, 2008) and Leadership Innovativeness (Jakovljevic, 2018; Wang et al., 2012) that can give contributions in terms of economic growth, enhancement of education system and competitiveness of employment. Knowledge capabilities and innovation in nurturing first class mentality are very essential and significant in Malaysia since it has become the main thrust in the implementation of the Tenth Malaysia Plan (10th MP) and Eleventh Malaysia Plan (11th MP). Accordingly, the Human Capital construct is selected to measure the students' innovation perception level due to the element that always underlies the requirement of Malaysia Plan. Numerous studies have attempted to explain human capital consists of a set of knowledge, abilities and skills of individuals to boost the innovation process (Popescu & Diaconu, 2008; Wright et al., 2001). The culture innovativeness is one of aspiration and one of the key factors for success of an organization. In fact, the selection of culture innovativeness construct is based on the innovation model developed by (Dobni, 2008) using exploratory factor analysis. He conducted an empirical study and innovation culture has been defined as multi-dimensional context, which includes the intention to be innovative, the infrastructure to support innovation, market orientation for innovation and implementation context. Leadership constructs in this study was based on the Big Five Model which consists of 5 factors introduced by Lewis R. Goldberg in 1981 in John & Srivastava, 1999 and one of the leaders who developed the theory of the Big Five is Allport. These five factors are Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism are highly associated and recommended model (King et al., 1996) in deciding an innovative person.

3. Method

3.1. Participants

Cluster random sampling was used to conduct the survey. Thus, 185 students from each group have been determined: engineering students and non-engineering students. A random distribution of instruments was made based on the specified features and method. However, the researcher considered response rate to create an unbiased sample and to provide adequate evidence for accountability and improvement purposes. Thus, (Cook et al., 2000; Nair et al., 2005) established 56% as an acceptable response rate for paper-based surveys in social research. Thus, 56% response rate of 370 corresponds to a response rate of 207 students. Only 223 of 370 respondents provided feedback within two weeks of data collection. Finally, out of 223 respondents, 117 are engineering students and the remaining 106 are non-engineering students. Engineering students are defined in this study as those who hold a Bachelor of Engineering degree in their respective fields of specialization Additionally, they are required to join the Board of Engineers Malaysia (BEM). Thus, it is mandatory for them to register with the organization once they have completed their studies. Non-engineering students, on the other hand, are not required to do so by the institution because they are classified as students of social science, pure science, or technical science.

3.2. Instrumentation

The pilot study involved evaluating all the instruments and the results led to the reduction from 132 items to 109 items for the actual study. All items were validated prior to presenting the test to participants. These 109 items measured 223 undergraduate students. Thus, Table 1 summarizes the instrument's items that were examined in the actual study. This is because some items were excluded since they did not meet the Rasch Measurement Model's requirements.The method section is written based on the question "**how was the problem solved**". If a manuscript proposes a new method, all information about the new method must be presented in detail so that the reader can reproduce the experiment (example in Figure 1). However, the author does not need to repeat the details of an established method, just use references and supporting material to show the established procedure.

It is important to note that methods must be written in the same order in the results section. The order of writing methods must also be logical according to the type of research. The method for one type of research will be very different from other studies. For example, writing survey research methods is very different from laboratory test research methods that involve a lot of equipment and materials. The method section can be created with several separate subtitles such as materials, tools, and data collection procedures.

Very likely, a novelty from a study is in the method section, even though the topic is the same as previous studies. New methods that are simpler but have the same ability to answer research questions are superior so that they can be replicated or applied by subsequent researchers. In addition, if the equipment has accuracy tolerance in reading data such as thermocouple, transducer, air flow meter, etc., it must also be stated clearly and honestly in the method section.

Table 1: Item Distribution List in Actual Test Instrument.

CONSTRUCTS	SUB-CONSTRUCTS	NUMBER OF ITEM	TOTAL OF ITEM
Human Capital	Knowledge	7	25
	Skills	11	
	Towering Personality	7	
Culture	Innovation Propensity	6	47
	Organizational Constituency	5	
	Organizational Learning	6	
	Creativity and Empowerment	12	
	Market Orientation	7	
	Value Orientation	4	
	Implementation Context	7	
Leadership	Openness	10	37
	Conscientiousness	4	
	Extraversion	7	
	Agreeableness	5	
	Neuroticism	11	
TOTAL			**109**

3.3. Data Analysis

In measuring the differences within the two groups of students; engineering and non-engineering, an inferential t-test was applied. The t-test is inferential tests that examine the significant differences based on a sample's demographic variables. Statistical Package for the Social Sciences version 26 was used to analyse the objective of this study.

While, for the second objective, Rasch Analysis approach was applied to analyse the data. Rasch Measurement Software; Winsteps was used to obtained item and person measures, item separation, item strata, and frequency. The innovation level threshold was determined using item strata, which can be calculated using the formula H= (4Q +1)/3, where Q is the item separation index obtained in Winsteps.

4. Result and Discussion

The inferential differentiation test, the t-test was utilized to determine if there are significant or meaningful differences between engineering students and non-engineering students. Prior to performing the inferential differentiation tests, all data were evaluated at the 0.05 level of significance with a 95% confidence level. A total of 223 respondents represents 117 non-engineering students (52.46%) and 106 engineering students (47.54%).

Based on Table 2, an independent-samples t-test was conducted to compare for construct Human Capital between two groups which are engineering students and non-engineering students. There was a significant differences for Human Capital constructs for Engineering Students (M=0.82, SD=0.12) and non-engineering students (M=0.76, SD=0.15) groups; t (221)=3.49, p=. 001. For Culture construct, there was a significant differences between Engineering Students (M=0.84, SD=0.12) and non-engineering students (M=0.77, SD=0.14) groups; t (221)=3.47, p=. 001. Lastly, there was a significant differences for Leadership constructs for Engineering Students (M=0.83, SD=0.11) and non-engineering students (M=0.77, SD=0.14) groups; t (221)=3.47, p=. 001. This study found that the overall level of innovation had statistically significant differences when compared with students' majors; engineering students and non-engineering students with the value ($p<0.05$).

The mean of each construct for both groups were computed, and the independent sample t-test was used to determine if the innovation construct of both groups is different. The results showed the innovation level for each construct of engineering students were greater than the non-engineering students. In fact, the engineering students were also higher on all factor that influence innovation, Human Capital, Culture and Leadership.Results and discussion can be made as a whole that contains research findings and explanations.

Table 2: T test Analysis based on the level of innovation by students' majors.

Construct	Mean Value		t	df	Sig (2-tailed)
	Engineering Students	Non- Engineering Students			
Human Capital	.8203	.7568	3.492	221	**.001**
Culture	.8371	.7775	3.472	221	**.001**
Leadership	.8349	.7757	3.475	221	**.001**

The second objective of this study is to develop an innovation profile of students. The profiling was developed based on the analysis from the involvement of 223 students and 109 of items in instrument. The objective of this profiling is to assess students' innovation level, which gives an indication on the students' achievement. In other words, the logit ruler has been developed with purpose to measure innovation level. Based on previous analysis, this instrument has item reliability of 0.86, item separation of 2.47, person reliability of 0.96 and person separation of 4.73. The calculated item strata is [4(2.47) +1] / 3= 3.62. Consequently, the level in instrument can be separated into ≈ 4 levels, which are Very High Innovative, High Innovative, Low Innovative and Very Low Innovative. Table 3 presented the result.

Table 3: Item Statistics.

Item Reliability	0.86
Item Separation	2.47
Strata	4 levels
Mean	0.00
Standard Deviation	0.33

Table 4 presented the threshold range and threshold logit. Thus, based on the threshold logit below, all respondents were divided by four innovation levels. Respondents with a person logit less than -1SD (-0.33) are grouped in Very Low level of innovation. In contrast, respondents with a person logit greater than +1SD (+0.33) are gathered as having a Very High level of innovation. Respondents in between above the person mean and less than or equal +1SD (+0.33) are sorted in High level of innovation. Whereas respondents in Low level of innovation are placed in between below the person mean and greater than or equal -1SD (-0.33).

Table 4: Threshold range and Threshold Logit.

Innovation Level	Threshold Range	Threshold Logit
Very Low	$< -1SD$	< -0.33
Low	$-1SD \leq Low < Mean$	$-0.33 \leq Low < 0.00$
High	$Mean < High \leq 1SD$	$0.00 < High \leq 0.33$
Very High	$> 1SD$	> 0.33

Table 5: Percentage and Frequency of Engineering and Non-Engineering students' level of innovation.

Group	Engineering Students				Non-Engineering Students			
Level	Very High	High	Low	Very Low	Very High	High	Low	Very Low
Frequency	99	4	2	1	105	7	3	2
Percentage	44.39	1.79	0.90	0.45	47.09	3.14	1.35	0.90

The distribution of respondents according to their innovation level is shown in Figure 1. The classification of respondents is based on their person measure logit. Overall, most respondents are in Very High level of innovation. According to both groups of students, non-engineering students demonstrate marginally more (n=105, 47.09%) than engineering students (n=99, 44.39%) in Very High Level of innovation. For the following

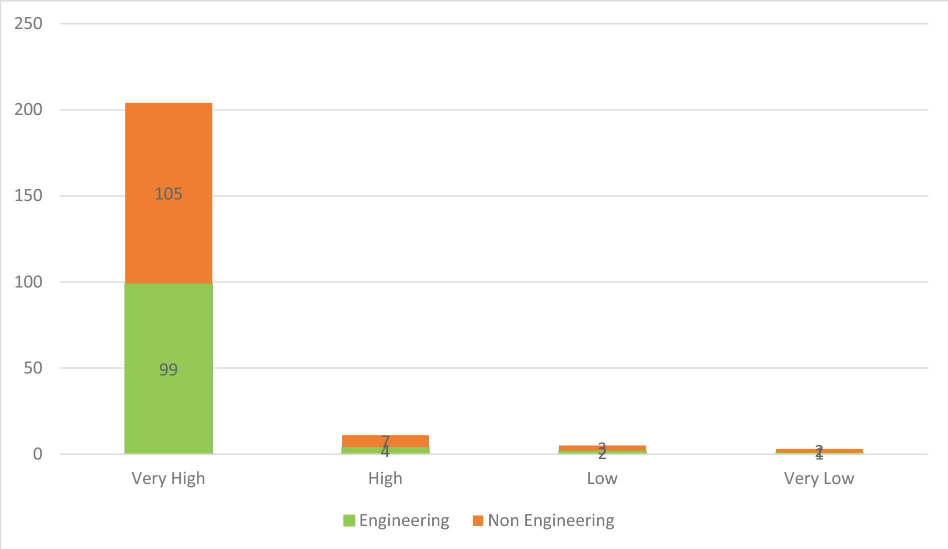

Figure 1: Innovation Level of Engineering and Non-Engineering Students.

levels, both groups reported a total of less than 10 students for each level. There are only 2 students of non-engineering and 1 engineering students in Very Low level of innovation. There are 7 and 4 non-engineering students assigned to the High and level of innovation, respectively. Meanwhile, only 3 non-engineering students and 2 engineering students are included in Low level of innovation.

5. Discussion and Conclusion

The study discovered that engineering students have a higher mean score for Human Capital, Culture, and Leadership Innovativeness. This demonstrates that engineering students are more innovative than other students. Students of engineering contribute positively to human capital, culture, and leadership constructs. As a result, engineering education has grown and increased demand to efficiently train a diverse group of engineers for these challenges. Parallel to this report, Law and Breznik (2017) asserted that engineering students and non-engineering students exhibit substantially different levels of innovativeness. Though, as compared to non-engineering students, there are substantially higher levels of attitude, learning encouragement, self-efficacy, and entrepreneurial purpose.

A thorough understanding in science and engineering technology enables engineering students to think innovatively, experience them through collaborative innovation, which is becoming increasingly crucial. In other words, knowledge and innovation are inextricably linked, yet they propel economies worldwide. Additionally, the development of future engineers entails the creation of innovative products that are competitive in global marketplaces (Genco et al., 2012), as the learning of engineering skills enables them to improve the quality of their designs.

The importance of an innovative culture in engineering education was stressed by the necessity to develop and promote educational activities and curricula that are effective in preparing students for the future (Jamieson & Lohmann, 2012). However, Duderstadt (2010) claimed that innovation occurs not only within the curriculum, but also within a broader context that encompasses engineering education and practice. Thus, engineering education and practice foster students' inventiveness to contribute significantly to socioeconomic progress. As a result, engineering capabilities such as problem solving, design, and analytical thinking have become indispensable, even for those who study and work in fields other than engineering. In this instance, it is demonstrated that the developed measurement instrument observed the presence of more innovative engineering students compared to non-engineering students, albeit with a very little difference.

Since innovation in engineering is normally underestimated and poorly understood, it is necessary to investigate ways to increase the level of innovation in the national economy. Jamieson and Lohmann (2012) previously said that one of the most significant difficulties facing engineering education is the requirement for engineers who are capable of successful innovation. Despite the fact that this study demonstrates that engineering students are more innovative than non-engineering students, innovation is not a core component of engineering education (McKenzie et al., 2004; Millet et al., 2017). From this circumstance, it is obvious that knowing the engineering student experience is insufficient to generate innovation.

However, the findings of this study corroborate those of Genco et al. (2012) from the University of Massachusetts, who found that freshman engineering students are more innovative than seniors, a finding that is consistent with the findings of this study. The other concept tested in their study showed that both freshman engineering and senior groups produced concepts with similar (high) levels of quality and feasibility. It is determined that the parallels between this study's findings and those of Genco are because both studies assessed engineering students' innovation level and capability for innovation.

Surprisingly, when non-engineering students are compared to engineering students, the number of engineering students with the highest degree of innovation is less than six. This demonstrates that while engineering students achieve a high score on independent t-test analysis, the number of students with the highest level of innovation is low in comparison to non-engineering students during profile analysis. The logit ruler was designed with the purpose of measuring ability, and hence it may be used to assess learning results for different individuals (Omar et al., 2010). It can be used to define a student's profile, and most importantly, it enables interactive validation of a question construct. It is a commendable innovation in which the capability of the 'ruler' transforms ordinal data into quantifiable scale. It provides a much clearer understanding, which makes it easier to make quick and simple decisions. With its predictive capability, the Rasch Model has made it extremely useful for overcoming missing data (Rashid et al., 2008).

While the two groups (engineering and non-engineering students) not too substantial differed, the significant differences still exist, and null hypothesis was rejected. Due to the fact that sample sizes are considered equal when the bigger group is less than 1.5 times the size of the smaller group (Gliner et al., 2011) , no effect size would need to be estimated. The variation in the number of items for each dimension may also lead to these findings being inconsistent. Thus, it may be inferred that the level of innovation demonstrated by engineering students is contingent on their exposure to innovation programmes or curricular during their studies. From first year of study, both engineering students and non-engineering students concerned about additional innovative ways to create capacity. Additionally, different techniques have been considered, including instructors who are interested in innovation, assisting them in pursuing such a route, and also investigating what is required. Finally, the events scheduled were driven not only by a desire to foster future innovation, but also by an interest in innovation. Given that the outcomes in this study were lower than expected, it is also because these engineering students come from diverse backgrounds, with some already having experience in subjects related to innovation and having been exposed to innovation competitions.The conclusion section contains a summary of the research findings, which correlate with the research objectives written in the introduction. Then state the main points of the discussion.

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References

[1] Abdullah I, Omar R, Panatik SA. A literature review on personality, creativity and innovative behavior. International Review of Management and Marketing. 2016;6:177–182.

[2] Ahmad Z, Abdullah S. Pembudayaan inovasi di politeknik dan kolej komuniti. 2015.

[3] Amabile TM. A model of creativity and innovation in organizations. Research in organizational behavior. 1988;10:123–167.

[4] Dakhli M, De Clercq D. Human capital, social capital, and innovation: A multi-country study. Entrepreneurship & regional development. 2004;16:107–128.

[5] Dobni CB. Measuring innovation culture in organizations. European Journal of Innovation Management. 2008;11:539–559.

[6] Duderstadt JJ. Holistic engineering education. Germany: Springer; 2010. Engineering for a changing world. p. 17–35.

[7] Ferguson Daniel M, Ohland Matthew W. What is engineering innovativeness? International Journal of Engineering Education. 2011;28.

[8] Ferguson DM, Jablokow KW, Ohland MW, Purzer Ş. Identifying the characteristics of engineering innovativeness. Engineering Studies. 2017;9:45–73.

[9] Fonseca T, de Faria P, Lima F. Human capital and innovation: The importance of the optimal organizational task structure. Research Policy. 2019;48:616–627.

[10] Genco N, Hölttä�Otto K, Seepersad CC. An experimental investigation of the innovation capabilities of undergraduate engineering students. Journal of Engineering Education. 2012;101:60–81.

[11] Gliner JA, Morgan GA, Leech NL. Research methods in applied settings: An integrated approach to design and analysis. London, UK: Routledge; 2011.

[12] Hurt HT, Joseph K, Cook CD. Scales for the measurement of innovativeness. Human Communication Research. 1977;4:58–65.

[13] Jakovljevic M. A model for innovation in higher education. South African Journal of Higher Education. 2018;32:109–131.

[14] Jamieson LH, Lohmann JR. Innovation with impact: Creating a culture for scholarly and systematic innovation in engineering education. Washington: American Society for Engineering Education; 2012. p. 77.

[15] Kanter RM. Change masters. New York, USA: Simon and Schuster; 1984.

[16] Kessler A, Pachucki C, Stummer K, Mair M, Binder P. Types of organizational innovativeness and success in Austrian hotels. International Journal of Contemporary Hospitality Management. 2015;27:1707–1727.

[17] Law KM, Breznik K. Impacts of innovativeness and attitude on entrepreneurial intention: Among engineering and non-engineering students. International Journal of Technology and Design Education. 2017;27:683–700.

[18] Manzini E. Design, when everybody designs: An introduction to design for social innovation. Massachusetts, USA: MIT Press; 2015.

[19] McKenzie LJ, Trevisan MS, Davis DC, Beyerlein SW. Capstone design courses and assessment: A national study. Paper presented at the Proceedings of the 2004 American Society of Engineering Education Annual Conference & Exposition. 2004.

[20] Menold J, Jablokow KW, Ferguson DM, Purzer S, Ohland MW. The characteristics of engineering innovativeness: A cognitive mapping and review of instruments. International Journal of Engineering Education; 2016;32:64–83.

[21] Millet C, Oget D, Cavallucci D. Open the 'black box'creativity and innovation: A study of activities in R&D departments. Some prospects for engineering education. European Journal of Engineering Education. 2017;42:1000–1024.

[22] Mulder M. Conceptions of professional competence. International handbook of research in professional and practice-based learning.Germany: Springer; 2014. p. 107–137.

[23] Oehlberg L, Leighton I, Agogino A, Hartmann B. Teaching human-centered design innovation across engineering, humanities and social sciences. International Journal of Engineering Education. 2012;28:484.

[24] Omar MZ, Rodzo'An N, Saidfudin M, Zaharim A, Basri H. Easier analysis and better reporting using Rasch model to handle rank data in engineering education research. RCEE & RHEd. 2010.

[25] Passig D, Cohen L. Measuring the style of innovative thinking among engineering students. Research in Science & Technological Education. 2014;32:56–77.

[26] Popescu C, Diaconu L. Human capital and innovation. Romania: Analele Universitatii din Oradea, Forthcoming; 2008. Available from: https://ssrn.com/abstract=1099025

[27] Rashid RA, Abdullah R, Ghulman HA, Masodi MS. Application of Rasch-based ESPEGS model in measuring generic skills of engineering students: A new paradigm. Engineering Education. 2008;5:591–602.

[28] Schar M, Gilmartin S, Harris A, Rieken B, Sheppard S. Innovation self-efficacy: A very brief measure for engineering students. Paper presented at the Proceedings for the American Society for Engineering Education Annual Conference, June 25–28. Columbus, OH. 2017.

[29] Sommer LP, Heidenreich S, Handrich M. War for talents—How perceived organizational innovativeness affects employer attractiveness. R&D Management. 2017;47:299–310.

[30] Sullivan A, Sheffrin S. Economics: Principles in action. Upper Saddle River, New Jersey: Pearson Prentice Hall; 2003.

[31] Urabe K. Innovation and Management International Comparisons. Berlin: Walter de Gruyter; 1988. Urabe K, Child J, Kagono T, editors. Innovation and the Japanese management system. Available from https://books.google.com.my/books?id=EkEAI9cRKfsC&pg=PA3&lpg=PA3&dq=Innovation+and+the+Japanese+management+system&source=bl&ots=ErwUjfxUMt&sig=ad_ob5g1yikUlXoqHCUjrUEEz6k&hl=en&sa=X&ei=wlq0VPXvHZG3uQSV9IGwBQ&ved=0CBwQ6AEwAA#v=onepage&q=Innovation%20and%20the%20Japanese%20management%20system&f=false

[32] Van der Panne G, Van Beers C, Kleinknecht A. Success and failure of innovation: A literature review. International Journal of Innovation Management. 2003;7:309–338.

[33] Wang H, Begley T, Hui C, Lee C. Are the effects of conscientiousness on contextual and innovative performance context specific? Organizational culture as a moderator. The International Journal of Human Resource Management. 2012;23:174–189.

[34] West MA. A measure of role innovation at work. British Journal of Social Psychology. 2987;26:83–85.

[35] West MA. Sparkling fountains or stagnant ponds: An integrative model of creativity and innovation implementation in work groups. Applied Psychology. 2002;51:355–387.

[36] Wright PM, Dunford BB, Snell SA. Human resources and the resource based view of the firm. Journal of Management. 2001;27:701–721.

[37] Zaini U. Budaya inovasi prasyarat model baru ekonomi. Johor: Universiti Teknologi Malaysia Press; 2010.

[38] Zlatkin-Troitschanskaia O, Pant HA, Lautenbach C, Molerov D, Toepper M, Brückner S. Modeling and measuring competencies in higher education. Germany: Springer; 2017.