Validity and Reliability of Green Competencies Instrument for Automobile Technology Programme Using Rasch Model

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Abstract
This article aims to determine the validity of developed constructs and check the reliability of the newly developed instrument named as Questionnaire on Green Competencies for Automobile Engineering Technology (QGCAET) for the Automobile Technology Programme in Nigerian Universities. The instrument consists of 170 elements measuring four constructs namely Technical Green Competencies; Managerial Green Competencies; Personal Green Competencies and Social Green Competencies and was administered to 299 respondents made of Lecturers, Technologists and Final- Year Students of Automobile Engineering and Technology programme in Nigeria universities. The Rasch model was used to examine the validity and reliability of the items. From the analysis point of view, the polarity of the elements indicates that the correlation of the point measure (PTMEA CORR) of 170 elements of green competencies is between 0.00 and 0.55. The summary statistics show that the reliability of the items and the separation of the items of the green competencies instrument are 0.98 and 6.46, respectively. Similarly, the item reliability of each construct is between 0.96 and 0.99, and the reliability of the person is between 0.79 and 1.97, respectively. In terms of item fit statistics, a total of 157 items are found to be fit to achieve the objectives of the study. The result also indicates that the range of fit for the four (4) identified green competencies constructs is between 0.61 and 1.49 signifying that all the constructs are in harmony in measuring the items in the constructs, so suitable in achieving the objectives of the research.

Keywords: Rasch Model; Sustainable Development; Green Competencies; Automobile Technology Programme; Validity: Reliability.

Introduction

Environmental pollution and other climate trends are bringing about damaging effects such as rise in sea level, persistent drought and changes in the weather pattern. These results of this changes have adverse effects, especially on sustainable development in terms of economic and social activities all over the world (Heong, Sern, Kiong, Mohaffyza, & Mohamad, 2016). Approaches such as the transformation of the economy to encompass sustainable development were the long-term practical measures taken by many developed countries like Japan, Germany and Britain to alleviate these environmental challenges. Industries are moving towards the use of non-polluting, low carbon emission materials, to a more efficient manufacturing process with limited use of unrenewable energy. The efforts to change the economy to a green economy model is making a rapid significant change in workforce demand in the labour market. Some entire new green jobs have been created in the industries and efforts are on going to transform the existing jobs in the industries to accommodate green concepts. For instance, in the automobile industry, engineers require green competencies to work with latest technologies in fuel-efficient green automobiles. The change of skill required in the opinion of Heong et al., (2016), is, pervasive, a general trend and it calls for a huge effort to revisit the programmes offered by the training institutions to embed "green" elements into the training curricula, because "green" job specification requires "green competencies" for effective production.

For this reason and in recent times, Adzmi et al. (2018) highlighted that, for greening the economy, attention was focused on green competencies in which industries and other firms introduced several ways to train their workforces for green practices. Consequent upon, factors like world economic downturn and ecological problem which automotive products are one of the contributing factors to the later pose many countries in the world to adopt the transition to greener economy by embedding green competencies into various occupations. More so, as a result of the authentication that follows the agreement on the green economy by world leaders during the Rio+ in June 2012, Nhamo, (2014) reported that the world is ready to apply the greener economy as a basis to achieve sustainable development, eliminate poverty and inequality and create jobs.

Accordingly, Strietska- Illina et al. (2012) reported a study conducted in 21 countries by ILO, which represent per cent of the world population indicated that economies shifting to greener production can create more jobs, if they deal effectively with the

upcoming structural change and transformation of the existing jobs. Hence, the pace of competencies needs and change in labour markets is increasing by the shift to a green economy. With regards to this, Stroud, Fairbrother, & Evans, (2015) stated that, transformation to a green economy will not only produce new jobs but will also alter the scope of the current jobs. Stating further, Stroud et al., (2015) emphasised that green competencies that will match the green jobs will involve a review of the current curriculum of educational programmes, requirement standards and teaching programmes, retraining of instructors and trainers. To this effect, UNESCO, (2012a) also informed that sustainability cannot be achieved only by technological solutions or financial instruments but by changing the way people think and act. In other words, through education. This means that employers and trainers should work together on these changes. Therefore, these changes clearly show the need to link the green economy to sustainable development via developing green competencies in Automobile Engineering and Technology programme in Nigeria. The developed competencies set needs to be measured to assure its trustworthiness to fit as relevant green competencies for automobile technology programmes in universities in Nigeria. This current study addressed this issue.

To further stress on UNESCO's assertion, Acedo, 2014; Chikwendu, Okoroji, Ikeogu, & Ejem, (2018) shows that sustainable development cannot be achieved without education and without adequate relevant green competencies for jobs, with particular reference to the automotive sector. While Nigeria is lagging in global sustainability in most of the sectors of economy according to Uzoma, Nnaji, & Nnaji, (2012), the development of green competencies to increase the productive chances of students in workplaces becomes vital and essential as it helps in greening the economy. This calls for a proactive need to include green competencies into the educational programme curriculum in universities in Nigeria, especially, engineering education to enhance the chances of sustainable development in the nation Nigeria. Engineering and Technology Education has been exemplified by the great economies of the world as the engine room for the technological and industrial advancement necessary for economic and national development. The notion of engineering education according to Ekpobodo, (2014), is to prepare students' broad knowledge of new technology through engineering skills profession. Ekpobodo's opinion aligns with the submission of Borhan, (2012), who also emphasized that the aim of engineering education is to equip engineering education graduates with adequate knowledge and skills through the use of PBL. Engineers are visionary people who create things by making use of technology to integrate our environment and develop oneself and others. Engineering education simultaneously play an active role and contribute to sustainable development by creating learning environments for students. In Nigeria, Automobile Engineering and Technology Education is offered as one the engineering education programs. It is taught at both Universities and Polytechnics, and one of their specific goals is to: provide the technical knowledge, skills and attitudes necessary for industrial, commercial and economic development as it relates to the changes in the demands of the environment.

Building on the above, a report by the FME, (2019) & Federal Republic of Nigeria (2015) hinted on the thought of the need to integrate the principles of sustainability into the country's policies and programmes in a bid to achieve the goal of millennium development goals on sustainability (MDG). To prove their level of seriousness and importance placed on reversal of natural resources, a joint meeting between officials of the Federal Ministry of Environment and the Director of International Labour Organisation ILO in the capital city Abuja in 2016, was held to explore the possible avenues to create green jobs opportunities in Nigeria. The top agenda of the meeting was to develop three- year plan that would contribute to the creation of green jobs especially in production and manufacturing sectors, renewable energy and waste management (ILO, 2016). The effective realisation of this programme will however, require the integration of green competencies into the training programme to train competent personnel that will facilitate the running of green jobs, especially in the automotive sector. This study therefore developed a set of green competencies required to train automobile technology students in universities in Nigeria. The developed green competencies have to undergo screening processes to ascertain its validity and reliability, that is what the use of Rasch analysis in this study has helped to achieve.

Green Competencies

The International Labour Organization ILO, (2015) defined green competencies as, the technical skills, knowledge, values, and attitudes essential by the workforce to develop and support sustainable development in businesses, for industry and the society. In the same vein, Corral-verdugo, (2002) described green competencies to be comprised of two key elements, i.e., environmental knowledge and environmental skills, which need to be employed by the ecological requirement demanded by the society. In general, green competencies can be seen as sustainability competencies relating to the knowledge, values, attitudes and the technical skills needed in the workforce to support and develop sustainable development (social, economic and environmental outcomes) in various organisations and the entire community.

At this juncture therefore, having explained what sustainable development meant and the role that should be played for integrating green competencies concepts in terms of knowledge, skill and attitudes into

the programme of automobile technology in Nigeria, it is pertinent to classify green competencies to be included into the automobile technology programme. With regards to the above, Pavlova, (2014) came up with the following description of green competencies, they include cognitive competencies (**Technical**- for example, environmental awareness and a willingness to learn about sustainable development, systems and risk analysis, skills to assess, interpret and understand both the need for change and the measures required, Innovative skills to identify opportunities and formulate new strategies to meet ecological challenges); Interpersonal skills (**Managerial**- e.g., coordination, management and business skills to promote holistic and interdisciplinary approaches covering economic, social and ecological goals, and to discuss conflicts in complex environments; Intrapersonal competencies (**Personal**- to help workers learn and apply new technologies and process adaptability and transferable skills required for green work, using low-carbon technology to provide Opportunities for entrepreneurial skills); and **Social** competencies- i.e Communication and negotiation skills for discussing issues of interest, marketing skills to promote products and more environmentally friendly services).

UNESCO (2016) recognised Technical Green Competencies (**TGC**) to include the following; knowledge of new materials, technologies, and energy efficiency to proffer technical solutions; knowledge cutting across energy issues, knowledge of automotive designs to adapt eco-friendliness, knowledge of automotive manufacture for environmental protection, quality standards; renewable energy legislation and environmental protection. Similarly, Gudanowska, Alonso, & Törmänen (2018) expresses that Technical Green Competencies provides an understanding of and proficiency in an activity, especially one that consists of methods, processes, procedures, or techniques; specialized knowledge, the analytical ability within that specialty, and facility in the use of the tools and techniques of the specific discipline. The above statement makes technical green competencies to be vital in both new and existing jobs.

Given the aforementioned and in aligning Technical Green Competencies to automobile engineering and technology programme, NUC-BMAS, (2016) have highlighted the relevance of technical competencies to the automotive industries. Being defined as the knowledge and enabling abilities required for prospective jobs in automotive industry, Technical Green Competencies include plant/ equipment operation, basic knowledge of sciences, automobile fundamentals, practical skills, service and maintenance, manufacturing and construction, automotive design. To add up to these facts, the United States Department of labour, (2016) have summed up the list of technical competencies for engineering education, defining it as knowledge, skill and abilities which are needed in various industry, its components are; engineering design, foundations of engineering, operation and maintenance, manufacturing and construction, sustainability, society & environmental impact, quality control & Assurance, Safety, Health, Society & Environment. They function more as critical work performance tasks.

Zolkifli, Kamin, Bin, Latib, & Buntat (2016) noted that the workforce in this era of green technology should have green competencies such as management skills, leadership, teamwork, problem- solving and decision making skills, which would allow them to be better people in their jobs and for jobs inclined to sustainability. Hence, Management can be seen as an act of planning, organising and coordinating the activities of an organization including directing the efforts of its employees to accomplish its objectives through the utilization of available capital, material, technological and human resources. To align managerial skills to green technology, Ploum, Blok, Lans, & Omta (2017) established that managerial green competencies (**MGC**) encompass an individual's abilities to create an efficient organization, team building, delegate responsibilities and capable of motivating others in a workplace. Ploum et al (2017) also mentioned strategic thinking, leadership and planning, project management and team management as important green competencies needed for green jobs.

Personal green competencies (PGC) are among the green competencies suggested by researchers that are required to combat the range of sustainability challenges in the economy, the environment and society. Defined by Kolmos, Hadgraft, & Holgaard (2016) and Gudanowska et al., (2018) as the set of competencies that portray the ability of an individual to be conscious of their values; adhere to professional ethics; plan their career path; reflect on experience; improve their future practices and engage in lifelong learning. Described by the United States Department of Labour (2016) as foundational competencies that covers a group of competencies, and apply to multiple career fields, personal effectiveness competencies are practical capabilities such as interpersonal skills, initiative, adaptability & flexibility, dependability & reliability, lifelong learning, teamwork. Others include; self-reliance, creativity, problem-solving and decision making skills and integrity/ honesty. The department further emphasized that personal effectiveness competencies are generally learned in the home or community and are refined over a while at school and in the workplace.

Social Green Competencies (**SGC**) are any set of competencies that facilitate interaction and communication with others where social rules and relations are created. Several researchers such as Kolmos et al (2016); Ploum et al, (2017); Gudanowska et al., (2018) believed that social competencies are vital in building a relationship between an organisation and customers, and also enhance cooperation and exert influence within the cooperation. Regarded in

some instances as a transversal skill, it embraces competencies like self- discipline, enthusiasm, perseverance, self- motivation, compassion, integrity and commitment. Others include global awareness, respect for diversity, conflict resolution and respect for sustainability, marketing skills and communication skills. These identified four (4) Green Competencies constructs with several items that make up the study instrument shall be tested to ascertain its validity and reliability.

Validity and Reliability Using the Rasch Model

Validity refers to the degree that a developed test instrument can accurately estimate a quantitative data. In this manner, determining the accuracy of a test tool can guarantee the effectiveness of the sample study (Yasin, Yunus, Rus, Ahmad, and Rahim, 2015). In the interim, reliability is the extent in which research test instruments can be expected to get a consistent result when repeated or perform consistent outcome when replicated (Rachman and Napitupulu, 2017). Rasch model methodology is attempted to look at the legitimacy and unwavering quality of the instruments utilized. Lately, the model Rasch is likewise described as Theory of Item-Response (IRT). It has been giving an alternative means of understanding the estimated measurement and also procedures for appraising the quality of a test instrument or questionnaire (Othman, Salleh, Hussin, and Wahid, 2014; Yasin et al., 2015). Applying Rasch Models may positively produce a valid and reliable quantitative data tool. Rasch Measurement Model likewise can prove the validity and reliability of a test instrument to a great extent. This is on the grounds that the utilization of Rasch Model gives an answer to any problem pertaining to validity of an instrument and also tenders valuable measurements and provides an uncommon chance to explore the validity of the instrument (Linacre and Linacre, 2008; Rachman and Napitupulu, 2017). Moreover, the Rasch model application in an investigation can work with and give more productive, solid and substantial measurement instrument. A study to recognize the validity and reliability of the quantitative data tool is vital to keep up with the exactness of the test tool (Othman et al., 2014). It is important to guarantee that the instrument can accurately estimate a quantifiable data.

Referring to this technique, Bond, (2010) specifies that Rasch models can be utilized as a strategy to develop new assessment instrument, evaluate an already existing test instrument and also to provide construct validity evidence of an assessment instrument. Linacre and Linacre, (2008) drew out five fundamental steps of the analysis employing the use of Rasch model. They are calibration/ alignment and estimation/assessment of abilities of items; the item polarity within the limits of the Measurement Model; the capacity of the items and instrument to function; establishing the relationship between the items and the respondents, likewise to items and respondents Infit/ Misfit. In view of this, the utilization of Rasch model in the validation of this instrument is to provide an evidence of the validity of the constructs in the QGCAET instrument, create more comprehensive data concerning the test instrument and bring out the meaning of the measured items. The criteria for reliability and the values for the Cronbach Alpha as it guides the study is found in Table 1.

Table 1. Rasch Model Benchmark for Reliability and Validity of Instrument

Criteria	Statistics Data	Minimum Requirement	Source
Validity	Item Polarity	PTMEA CORR >0	(Bond, 2010; Bond, Fox &Lawrence 2001)
	Infit/ Outfit	Infit and Outfit Mean Square (MNSQ) limit of 0.6 – 1.4 for Polytomy Data Z-Standard (ZSTD for -2 to 2)	(Bond, 2010)
	Separation Index (SE)	Items shows ≥ 2	(Bond & Fox, 2015)
Reliability	Person Reliability	Value > 0.8	(Bond & Fox, 2015; Rachman & Napitupulu, 2017)
	Item Reliability	Value > 0.8	(Bond & Fox, 2015; Rachman & Napitupulu, 2017)
	Cronbach Alpha	Value > 0.7	(Bond & Fox, 2015; Creswell, 2014; Creswell & Creswell, 2018)

Research Method

In this Quantitative study, the determination of the Green Competencies for Automobile Technology program was acquired by utilizing Questionnaire on Green Competencies for Automobile Engineering Technology (QGCAET). The instrument was designed to address the Green Competencies that are relevant for Automobile Technology programme in Nigerian Universities. Being a Five-Point Likert scale instrument with response rating of Not Relevant NR(1), Slightly Relevant SR(2), Moderately Relevant MR(3), Very Relevant VR(4) and Highly Relevant HR(5). The instrument comprises of four constructs, with a sum of 170 items. There are 70 items in the Technical Green Competencies construct (TGC), 50 items in the Managerial Green Competencies construct (MGC), 34 items in the Personal Green Competencies construct (PGC), and 16 measurement items in the Social Green Competencies construct (SGC). Examples of items for each constructs are as shown in Table 2.

For this reason, the instrument that is utilized to acquire the necessary information ought to be validated. The testing of the instrument is understood to be essential. This study plans to validate the instrument and measure its reliability by utilizing the Rasch model. By utilizing the model, the constructs built in QGCAET and their connected assessment can be evaluated in terms of consistency, dependability, and precision. The validity and reliability tests are performed on these key features of Rasch Analysis: (i) test reliability and the separation of the items and the respondent, (ii) recognize the polarization of the items measuring the constructs, and (iii) test the fit/ conformity of the items in the instrument (Linacre and Linacre, 2008). To achieve these, the procedures of using Rasch model to test validity and reliability are as follows: (i) calculate the reliability index of the test and the degree of separation between the item and the respondent, (ii) calculate the polarized PTMEA CORR value of the construct-based measurement item, and (iii) Calculate the fitness or conformity of instrument items developed based on MNSQ and ZSTD values (Bond and Fox, 2015; Rachman and Napitupulu, 2017). The Rasch model considers the potential of the respondents to respond to item questions and the difficulty level of the items itself. Item suitability analysis (item fitting) evaluates whether the instrument items can measure what they should measure. When an item is inappropriate, reframing or total removal of the item is considered. The benchmark for establishing the effectiveness and trustworthiness of the instrument are shown in Table 1.

Table 2. Excerpts of constructs and items from QGCAET

	Items	Responses				
		NR (1)	SR (2)	MR (3)	VR (4)	HR (5)
Technical Green Competencies	**Basic Sciences**					
	Knowledge of General Chemistry					
	Alternative Energy					
	Knowledge of application of alternative energy- Biofuels, Biomass, Ethanol					
	Waste Management					
	Ability to select and use recyclable materials & products to minimise waste					
Managerial Green Competencies	**Communication Skills**					
	Ability to Communicate with people from various background					
	Entrepreneurial skills					
	Anticipate technological developments by interpreting surrounding, societal & economic trends					
Personal Green Competencies	**Creativity & Innovative skills**					
	Ability to design new products from scraps					
	Adaptability & Flexibility					
	Adjust to new ideas and changes					
Social Green Competencies	**Self- confidence**					
	Strong determination to complete task/ achieve objectives					
	Perseverance & Stress Management					
	Ability to work at extra hours					

The total number of the respondents are 299 and they are chosen by utilizing purposive sampling strategy. In the current study, the respondents are the Lecturers, Technologists and Final –Year students of the Automobile Technology Program in Five Universities in Nigeria. The students are in the fourth or fifth year of their study program and had undergone training in the required competencies in their various areas of specialization of engineering education. The analysis by the Rasch model was carried out by the use of version 3.72.3 of Winstep Software. The table of distribution of respondents and their institution is found in Table 3.

Findings and Discussion of Results

Person and Item Reliability and Separation Index

The statistics as analysed for the reliability and separation of items based on the developed instrument is examined in this part of the article. In Table 4, with 299 person measuring 170 items based on the quantitative instrument, the QGCAET instrument item reliability is 0.98 and item being separated at 6.46. This indicates that QGCAET instrument items could perhaps be categorized in 6 groups. Equally, the value for person reliability for the QGCAET instrument stands at 0.79 with separation of person value of 1.97. 1.97 value is a demonstration that the respondents' ability to answer the questions in the instrument can be classified into 2 groups. Person reliability interpretation measured against Alpha Cronbach (KR-20) produced a score of 0.82 which is slightly higher than the person reliability. Table 4 itemizes the obtained item reliability and separation index for each constructs in the QGCAET instrument. Item reliability value as indicated for a good number of the constructs is above 0.7 (0.96-0.99). These values indicate a high level of acceptability of each of the constructs (Bond & Fox, 2015). The item separation ranges from 4.85 to 11.30. Majority of the item separation indexes are equal or greater than 2, hence, considered as highly valid for Rasch model. Similarly, Table 5 and 5.a provides the statistical summary of instrument reliability of items and person measured for extreme and non- extreme value. Table 6 tabulates the summary of item and person reliability and separation based on real root mean square error.

Table 3. Distribution of Respondents of the Study

S/N	Institution	No of Lecturers	No of Technologists	No of Students
1	Abubakar Tafawa Balewa University - **ATBU**	16	7	60
2	Federal University of Technology Minna – **FUT- Minna**	13	6	47
3	Modibo Adama University of Technology Yola- **MauTech**	15	7	48
d4	Benue State University Makurdi –**BSU**	13	5	25
5	Elizade University Akure **EU**	10	4	23
Total	5	67	29	203
Grand Total	299			

Table 4. Item/ Person Reliability and Separation Index for QGCAET Instrument

Constructs	Total Items	Item Reliability	Item Separation Index	Person Reliability	Person Separation Index
Technical Green Competencies	70	0.96	4.85	0.74	1.69
Managerial Green Competencies	50	0.99	11.30	0.72	1.02
Personal Green Competencies	34	0.99	8.97	0.69	0.83
Social Green Competencies	16	0.99	8.52	0.66	0.52

Table 5. Summary of Item and Person Reliability from QGCAET Analysis Table
Summary of 299 measured Person

	Total Score	Count	Measure	Model	Infit		Outfit	
					MNSQ	ZSTD	MNSQ	ZSTD
Mean	508.5	108.0	3.74	.22	1.01	.0	1.00	.1
SD	11.1	.0	.52	.03	.23	1.3	.28	1.2
Max	525.5	108.0	4.69	.29	1.61	2.9	1.69	2.6
Min	474.0	108.0	2.47	.17	.65	-2.4	.54	-1.9

Real RMSE .24 True SD .46 Separation 1.97 Person Rel. - .79
Model RMSE .23 True SD .47 Separation 2.06 Person Rel. - .81
SE of Person Mean - .03
Person raw Score-to-Measure Correlation - .98
Cronbach Alpha (KR-20) Person Raw Score "Test" Reliability- .82

Table 5.a. Summary of 99 Measured Item

	Total Score	Count	Measure	Model Error	Infit		Outfit	
					MNSQ	ZSTD	MNSQ	ZSTD
Mean	1399.9	299.0	.00	.14	1.06	.1	1.00	-.2
SD	83.5	.0	1.06	.05	.34	3.3	.31	3.1
Max	1485.0	299.0	3.48	.32	2.02	8.6	1.90	9.1
Min	990.0	299.0	-2.23	.07	.44	-9.0	.41	-8.6

Real RMSE .16 True SD 1.05 Separation 6.46 Item Reliability - .98
Model RMSE .15 True SD 1.05 Separation 6.89 Item Reliability - .98
S.E of Item Mean = .11
Global Statistics:
UMean - .0000 USCALE = 1.0000

Table 6. Summary of Item and Person Reliability and Separation based on Real Root Mean Square Error

Item Reliability			Person Reliability		
No of Items	Reliability	Separation	No of Persons	Reliability	Separation
170	.98	6.46	299	.79	1.97

Item Polarity

In this part of the article, the effectiveness/ validity of the items is measured by the Point Measure Correlation (PTMEA CORR). Described as the rate of the instrument element polarity (item polarity). The polarizing items inspection is designed to determine if the constructs have been drafted to attain the goals of the study. If the PTMEA CORR value is positive (≥ 0), the item is said to measure what it should measure. On the contrary, a negative (≤ 0) value of the item is an indication of the inability of the item to measure the variables it was designed to estimate, hence, the item need to be revisited and/ or taken out as the case may be. This is because the item is not in focus or it is difficult for the respondents to answer. As found in Table 7, the constructs had a favourable coefficient of correlation from the output of the result which therefore establishes the validity of the measured competencies regarding item ability. (Linacre & Linacre, 2008; Suhairom, 2016). There are no items that need to be dropped based on polarity requirement because items are moving in one direction with the constructs.

Table 7. Polarity of items on QGCAET Instrument

Constructs	PT-MEA CORR				Total Item
	Min	Item	Max	Item	
Technical Green Competencies	0.08	TGC11	0.55	TGC20	70
Managerial Green Competencies	0.00	MGC26	0.42	MGC34	49
Personal Green Competencies	0.00	PGC21	0.36	PGC27	33
Social Green Competencies	0.00	SGC7	0.43	SGC12	16

Table 8. Item Polarity Based on PTMEA CORR for QGCAET Instrument

Constructs	Entry Number	Total Score	Total Count	Measure	PTMEA CORR	Item
Technical Green Competencies	*11	1423	299	+0.04	0.08	TGC11
	**21	990	299	+3.11	0.55	TGC20
Managerial Green Competencies	*29	1495	299	-6.10	0.00	MGC28
	**36	443	299	+8.15	0.42	MGC34
Personal Green Competencies	*23	1495	299	-5.96	0.00	PGC21
	**30	1195	299	+3.17	0.36	PGC27
Social Green Competencies	*6	1495	299	-5.90	0.00	SGC7
	**14	1145	299	+2.53	0.43	SGC12

*Minimum Value ** Maximum Value

From Table 8, it can be shown that each construct (with two items result for minimum and maximum value) produced a favourable PTMEA CORR value. Thus, no item in the instrument was removed because they all have obtained the least requisite PTMEA CORR score of ≥ 0. Furthermore, from Table 8, Technical Green Competencies, that is, the item 21 (TGC20) having a value measured at +3.11 means that the respondents found it most complex to be approved, so also is item 11 (TGC11) is 0.04 pointing out that the item is the most uncomplicated to be attempted by the respondents. Similarly, item 36 (MGC34) for Managerial Green competencies with a measured value of +8.15 shows that the respondents found the item too complex for their ability in answering the question, whereas, item 29 (MGC28) measures value of -6.10 is the easiest item to be answered by respondents. The logit value for item measures Personal Green Competencies in item 30 (PGC 27) is probably the item the respondents finds most difficult, in like manner, item 23 (PGC21) with value at -5.96 was considered easiest to answer by the respondents. Lastly, item 14 (SGC12) on Social Green Competencies with a measured value of +2.53 points to the direction of the most difficult item considered by the respondents and its corresponding minimum measure value is item 6 (SGC7) measuring -5.90 is considered the easiest item approved by the respondents. The high- value of PTMEA CORR gotten from the results of the respondents delineates the different ability levels of the respondents.

Item Fit Statistics

The suitability and appropriateness of items often referred to as fit statistics or item fit is the value of the Infit and Outfit Mean Square MNSQ. The observation of the MNSQ value is developed based on the item (fitting) in the construct measurement. Based on some suggestions in literature (Bond, 2010; Linacre, Linacre, 2008; Rachman & Napitupulu, 2017); Rachman & Napitupulu, 2017) to ascertain the applicability of the developed items, the Infit and Outfit MNSQ parameters must be 0.5 To 1.5 (Linacre and Linacre, 2008) (for multi-point data) and 0.7 to 1.3 (for two-point data). (Bond and Fox, 2015; Rachman and Napitupulu, 2017). When determining the harmony of the elements of the construct, more emphasis should be placed on the MNSQ of outfit rather than MNSQ of Infit. If the result shows rate beyond the range of 1.5 MNSQ, it indicates a complex item structure or is out of focus. However, if the result shows that the logit value

is less than 0.5, it also signifies that the respondents probably found the item to be simple and uncomplicated to be answered. (Linacre, 2012). Similarly, the Infit and Outfit ZSTD (z-standard) rate normally falls between the limit of -2.0 to +2.0. Notwithstanding, in case the values of Infit and Outfit MNSQ falls in the acceptable range, ZSTD value can be ignored (Bond and Fox, 2015; Suhairom, 2016).

Table 9 shows that the minimum and maximum Infit and Outfit MNSQ value for all the constructs met the requirements i.e 0.5-1.5 MNSQ range. It therefore means all the constructs are in harmony in measuring the items in the constructs, so suitable in achieving the objectives of the research.

Table 10 also shows that there are thirteen (13) items which have not met the requirement for the Infit and Outfit limit value of ≥0.5 or ≤1.5. six (6) of the items exceeded the limit value of outfit (≤1.5), while six (6) has not reached the minimum MNSQ value of ≥0.5. Likewise, Infit ZSTD value for item PGC16; SGC4; TGC31; TGC40; TGC55; PGC5 is obtained at a level significantly greater than (≥2.0), therefore, a review of the items for possible removal from the instrument and alternatively, for amendment of the items were viewed. However, in this study, a total of 157 items are found to be Fit based on the analysis of the Rasch Measurement Model hence, these valid items are maintained since they are able to achieve the objectives of the research, which is to measure automotive technology programme green competencies.

Table 9. Item and Person Fit Statistics for each constructs on QGCAET instrument.

Constructs	Item				Person			
	Infit MNSQ		Outfit MNSQ		Infit MNSQ		Outfit MNSQ	
	Min	Item	Max	Item	Min	ID	Max	ID
Technical Green Competencies	0.61	TGC66	1.48	TGC31	0.61	68	1.90	32
Managerial Green Competencies	0.73	MGC37	1.23	MGC41	0.49	39	1.81	43
Personal Green Competencies	0.65	PGC15	1.49	PGC18	0.37	17	2.23	20
Social Green Competencies	0.68	SGC5	1.46	SGC4	0.25	6	3.07	5

Table 10. Item fit for QGCAET Instrument

	Infit		Outfit	
Items	**MNSQ**	**ZSTD**	**MNSQ**	**ZSTD**
PGC28	0.75	-1.9	0.40	-3.7
PGC16	1.77	7.9	1.90	9.1
SGC4	1.68	7.3	1.69	7.5
PGC11	0.92	-0.2	0.38	-0.2
PGC22	0.92	-0.2	0.38	-0.2
TGC31	2.02	8.6	1.71	5.9
SGC11	0.76	-1.6	0.49	-3.1
TGC40	1.91	6.9	1.54	4.0
TGC55	1.92	7.0	1.58	4.3
PGC5	1.76	5.5	1.74	4.9
SGC6	0.76	-1.3	0.35	-3.4
SGC3	0.86	-0.6	0.44	-2.7
TGC42	1.54	3.3	1.43	2.4

Conclusions

The study draws the following conclusions:

1) The research instrument for determining the green competencies of automotive technology using QGCAET is highly reliable, standing at a 0.82 coefficient of reliability from Cronbach's Alpha benchmark requisite cut-off score of 0.7. In like manner, all the developed items have a high reliability and separation index of between 0.96 – 0.99. Therefore, this instrument could be replicated in another study following all the laydown procedures and standards and obtain the research expected outcome.

2) The value of PTMEA CORR for measuring item polarity is within the range of 0.00 and 0.55 for all items in the four constructs. Therefore, the effectiveness of the items was ascertained from its ability to quantify the unit variable it ought to measure. Hence, the instrument was able to achieve the objectives of the research.

3) The minimum and maximum Infit and Outfit MNSQ value for all the constructs met the requirements i.e 0.5-1.5 MNSQ range. However, 13 items have not met the requirement of the Infit and Outfit ZSTD Values. Their Infit and Outfit ZSTD range is above the defined threshold of -2.0 to +2.0. Based on the standard recommended as a solution to misfit items, the 13 misfit items can be deleted, or revised taking into consideration the objective to be achieved by the study. In addition, all the constructs are in harmony in measuring the items, so suitable in achieving the objectives of the research.

4) Employing the Rasch model, the outcome of the present study took a look at proposing that the instrument employed to determine the validity and reliability for measurement of the relevant green competencies for Automobile Technology programme within the framework of QGCAET.

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