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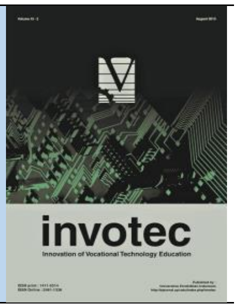

Process Assessment of Practical Projects in Mechanical Technology Using Confirmatory Factor Analysis

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A B S T R A C T

The need for uniformity in assessing practical projects in mechanical technology necessitated this study. This descriptive study employing a survey focused on process assessment of practical projects in mechanical technology using Confirmatory Factor Analysis (CFA). The population for the study was 237 technical education experts in Southwest, Nigeria. There was no need for the adoption of any sampling technique since the population was manageable. The instrument for data collection was the Process Assessment Technique Questionnaire (PATQ). The instrument was validated by three experts at face and content level. The reliability of the instrument was established using Cronbach Alpha coefficient method and a coefficient of 0.93 was obtained. The data collected on the research question were analyzed using mean and Confirmatory Factor Analysis (CFA). The CFA was done using Analysis of Moment Structures (AMOS) software. The findings of the study revealed that the proposed model for assessing practical projects in mechanical technology is valid and reliable having fulfilled all the conditions for convergent, construct and discriminant validity. Average Variance Extracted (AVE) of 0.66 and Composite Reliability (CR) of 0.94 were obtained respectively. Based on the findings of the study, it was recommended that the model be adopted in assessing practical projects in mechanical technology and other related areas in Vocational and Technical Education.

1. Introduction

Mechanical Technology is an integration of two different areas of specialization in technical education. It is a combination of both automobile technology and metalwork technology which aimed at promoting problem solving skills and enable recipients to fit into industrial production unit with avalanche of job creation opportunities in the society (Elisha, 2014; Giatman, Waskito, & Sihombing, 2017; Lemo & Olakotan, 2017; Mshelizah, 2012; Sudsomboon, 2014). However, skill acquisition in mechanical technology is centered on initiation of practical projects which will enhance students' participation and repetition of tasks to the point of being versed in performing the tasks Practical projects are the nucleus of skill acquisition in VTE programs and thus could be deduced that no meaningful skills can be acquired if practical activities do not support theoretical contents in VTE programs (Lemo & Olakotan, 2016; Waskitoa, Adila, & Hendri, 2020). Practical work enables students in the teaching and learning environment to observe and manipulate objects, materials, tools and machines to produce a visible product. Okoro (2006) asserted that a cardinal principle of VTE requires adequate repetitive training in practical work from the occupation, aimed at ensuring right habits of doing and thinking to the degree necessary for employment. Practical projects in mechanical technology involve various tasks. Tasks such as selection of materials, selection of appropriate tools and machines, measuring, marking out, cutting and manipulations of different kinds are important steps required in a producing a project. Feirer in Dangana (2011) stated that practical projects aid in organizing students' experiences to learn and solve problems.

Ogwo and Oranu (2006) noted that projects stimulate learning, improve students handling of tools and materials and also help in positively developing students' attitude to work. Similarly, practical projects offer students the opportunities to acquire skills and experience from the performed activities (Abdullah, 2013; Lemo & Olakotan, 2016). Furthermore, practical projects according to Corter et al. (2011) is a precursor to acquiring necessary skills which helps in strengthening the conceptual understanding of the course content. It must be noted that the minimum hands-on skill provided to the students and less experience on hands-on activities caused students to have less confidence in their practical ability and lead to incompetency in the world of work (Pereira & Miller, 2010). In a similar vein, a well marshaled practical class which utilizes various strategies would develop students' skills (Damon, Ahmad, & Rajuddin, 2008; Mohamad et al., 2017).

The position of Krivikas (2005) in the Edgar Dale's cone of experience revealed the importance of practical projects in VTE. The Edgar Dale's cone of experience revealed the various level of educational experiences to real life situations as effectiveness is recorded in active engagement in practical activities as shown in the cone below (See Figure 1):

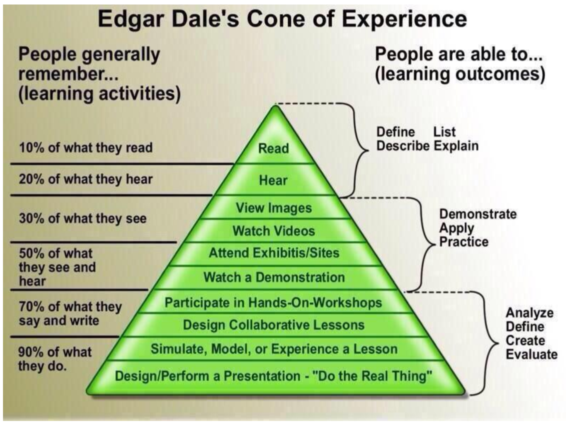

Figure 1. Edgar Dale's cone of experience

For effective process assessment of practical projects in mechanical technology, the use of suitable model which will assist teachers in planning and carrying out thorough assessment in the workshop becomes significant. Process assessment involves direct observation of students' activities and procedures in carrying out a task in a bid to ensure that adequate marks are awarded. Similarly, process assessment is a step-by-step guide outlined in order of magnitude and necessity that aid the assessor in assessing students' project per time. It has been observed that the present practice in VTE institutions is giving practical to students without any acceptable standard for assessment leaving students to contract the projects to artisans. VTE teachers are also often misguided as they assess the final project without the processes involved in carrying out the project. This is due to the lack of the necessary practical experience to relate with fundamentals in order to practice and to give examples resulted in the students not being able to relate theory with practice and apply their knowledge to solve practical problems (Isa et al., 2019). Hence, the need for a model for assessing practical projects in mechanical technology.

2. Psychomotor Domain Model

The model for assessing practical projects in mechanical technology is built on the Psychomotor Domain Model developed by Ferris and Aziz (2005). Ferris and Aziz (2005) identified recognition of tools and materials; handling tools and materials; basic operation of tools; component operation of tools; expert operation of tool; planning work operations and evaluation of outputs and planning means for improvement as essential components of the psychomotor domain model. The essence of the use of psychomotor domain model dwells on the fact that psychomotor domain itself includes physical movement, coordination, and use of the motor-skill areas. Therefore, the development of these skills requires practice through exposure to practical projects and works in the workshop. Thus, the practical projects and works are then measured in terms of speed, precision, distance, procedures, or techniques in execution.

2.1 Proposed model for assessing practical projects in mechanical technology

Based on the Psychomotor Domain Model, the proposed model for assessing practical projects in mechanical technology arranged hierarchically followed a time-tested procedure deemed appropriate in VTE institutions as displayed below:

- Selection of Correct Materials: The ability to select correct materials from the expanse of materials available to undertake a practical project is an important step in the production of a worthwhile project. Students therefore are expected to be able to choose correctly suitable materials for the project at hand.
- Selection of Appropriate Tools: Having excelled in the selection of correct materials, the selection of appropriate tools comes next. Students are expected to choose tools that will be appropriate in performing various operations deemed fit for the actualization of the project.

- Selection of Safety Wears: The need for safety in any workshop activity is of high importance. Students are then expected to select appropriately, safety wears that would prevent accidents of any sort while embarking on activities for the project.
- Taking Accurate Measurement: To prevent material wastage, accuracy in measurement taking is important for practical projects.
- Taking Accurate Marking Out: Taking accurate marking seconds measurement and thus also prevents material wastage. This skill however is a sine-qua-non in carrying out practical projects.
- Taking Accurate Cutting of Materials: Accuracy in cutting materials for a project is indeed needful and essential. Students therefore require skills for cutting of materials accurately.
- Application of Different Bench and Machine Operations: Since several processes are involved in carrying out practical projects, students are expected to apply all the needed operations both at bench and on the machine to actualize the project embarked on.
- Observation of Safety Rules: At this juncture, and even from the inception of the processes, strict observance of safety rules is paramount.
- Appearance/Finished Product: These entail checking the accuracy of the finished product and ensure that it conforms to the laid standard of the intended article without undermining its aesthetic.

It has been observed over time that students contract their projects to artisans because the teacher is interested only in seeing the final product. Hence, for skill acquisition in mechanical technology direct product assessment should not be encouraged rather process assessment. Therefore, the conceptual model intends to serve the purpose of process assessment of practical projects in mechanical technology. The study determined process assessment of practical projects in mechanical technology. Specifically, the study determined: Process assessment techniques for assessing practical projects in mechanical technology

3. Methodology

This study adopted a descriptive survey research design. A survey according to Gall, Gall, and Borg (2007) is a method of data collection using questionnaire or interviews to collect data from a sample that has been selected to represent a population to which the findings of the data analysis can be generalized. The population for the study was 237. No sampling technique was used for this study because the population was manageable. Process Assessment Techniques Questionnaire (PATQ) containing 9 items was developed and used for the study. The scaling responses for the instrument was based on adapted Likert Scale ratings viz: Strongly Agree (SA) – 5, Agree (A) – 4, Undecided (U) – 3, Disagree (D)-2 and Strongly Disagree (SD) -1. The instrument was subjected to face and content validation by three experts. The reliability coefficient of the instrument was determined using Cronbach Alpha coefficient, and a coefficient of 0.93 was established. The data generated was analyzed using descriptive and inferential statistics. The descriptive statistics of mean and standard deviation were used to answer the research question raised. Furthermore, as soon as the descriptive analysis was achieved, the normality of the data for each construct was ensured before proceeding to the structural model. The outliers were removed in order to assess the distribution of every variable in a data set. The normality assessment was done by assessing the measure of skewness of every item. The absolute value of skewness of 1.0 or lower indicates the data is normally distributed. Another method for normality assessment is by looking at the multivariate kurtosis statistic. However, SEM using Maximum Likelihood Estimator (MLE) is also robust to kurtosis violations of multivariate normality as long the sample size is large and the Critical Region (CR) for the kurtosis does not exceed 7.0.

Through CFA, the researcher instructs AMOS to calculate the standardized estimate and squared multiple correlations by clicking the respective box in the analysis menu. The standardized estimates indicate the factor loading for each item in a measurement model. Any item having a factor loading less than 0.5 was deleted from the measurement model. However, the researcher may not do so if the fitness indexes for that measurement model already achieved the required level. An item having low factor loading simply means that particular item is deemed useless to measure that particular construct. Keeping useless item in a model will affect the fitness index of the model. Thereafter, Confirmatory Factor Analysis (CFA) was used for the research question to determine which items are to be retained from the initial CFA model of each construct as well as their revised CFA model. Therefore, for every fitted model, all the factor loadings must be equal to or above 0.5. Also, the modification indices such as CFI, IFI, TLI must be above 0.90; the ratio of the Chi-square and the Degree of freedom (df) < 3 and RMSEA < 0.08. Hence, the revised models were performed wherever the initial CFA models did not meet up with the stated criteria.

4. Results and Discussion

4.1 Research question

What are the process assessment techniques for assessing practical projects in mechanical technology?

To answer research question one, mean and Confirmatory Factor Analysis were used. The result of the computation is as presented in Tables 1 and 2 as well as Figures 2 and 3.

Table 1. Process assessment techniques for assessing practical projects in mechanical technology

S/N	Item Statements	$\bar{x}$	S.D	Remarks
1	Selection of Correct Materials	4.22	.42	Agree
2	Selection of Appropriate Tools.	4.68	.58	Agree
3	Selection of Safety Wears	4.14	.54	Agree
4	Taking Accurate Measurement	4.54	.51	Agree
5	Taking Accurate Marking Out	4.16	.37	Agree
6	Taking Accurate Cutting of Materials	4.68	.47	Agree
7	Application of Different Bench and Machine Operations	4.00	.70	Agree
8	Observation of Safety Rules	4.95	.23	Agree
9	Appearance/Finished Product	4.32	.97	Agree

The data presented in Table 1 revealed 9 process assessment techniques for assessing practical projects in mechanical technology. The means for the items ranged from 4.00 to 4.68. Each mean is above the cut-off of 3.50 showing that all were process assessment techniques for assessing practical projects in mechanical technology. The standard deviation of the items also ranged from .23 to .97. This indicated that the respondents were close to one another in their opinions and that they were not far from the mean.

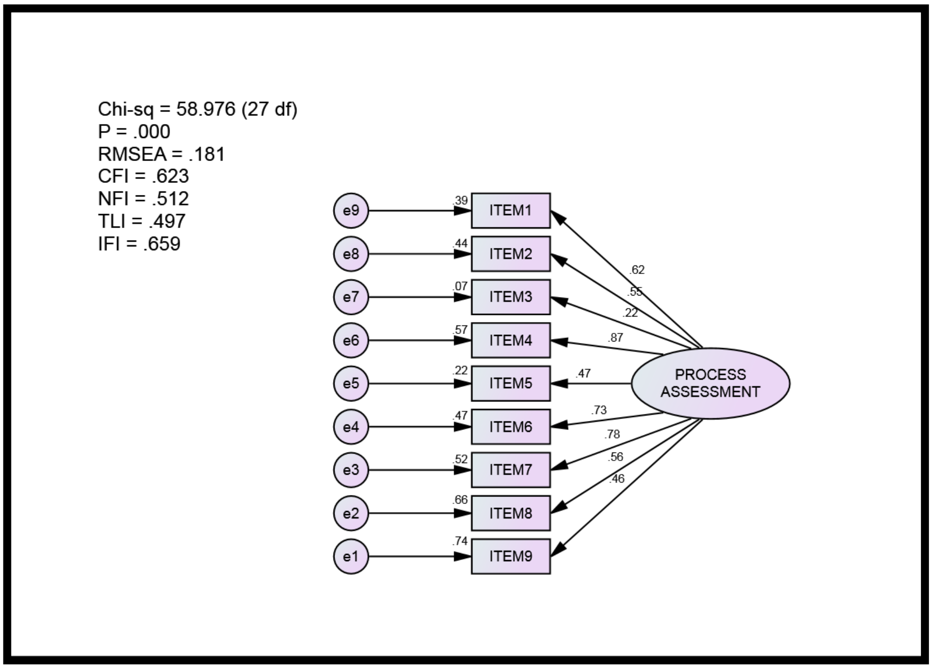

Figure 2. Initial model for process assessment techniques for assessing practical projects in mechanical technology

The initial model based on Confirmatory Factor Analysis (CFA) for Process Assessment Techniques for Assessing Practical Projects in Mechanical Technology was not found fitted and did not comply with a goodness model fit. The Chi-square = 58.976, df = 27, P = .000, the ratio of the Chi-square and the df = 2.18, NFI = .512 (< .90), CFI = .623 (< .90), IFI = .659 (< .90), TLI = .497 (<

.90) and RMSEA = .181 (> .080). Hence, in order to fulfill the requirements, the model was trimmed sequentially so that the items remaining will fit well to the data at P > 0.05 while the modification indices (NFI, CFI, IFI, TLI) and RMSEA measured up to the standard.

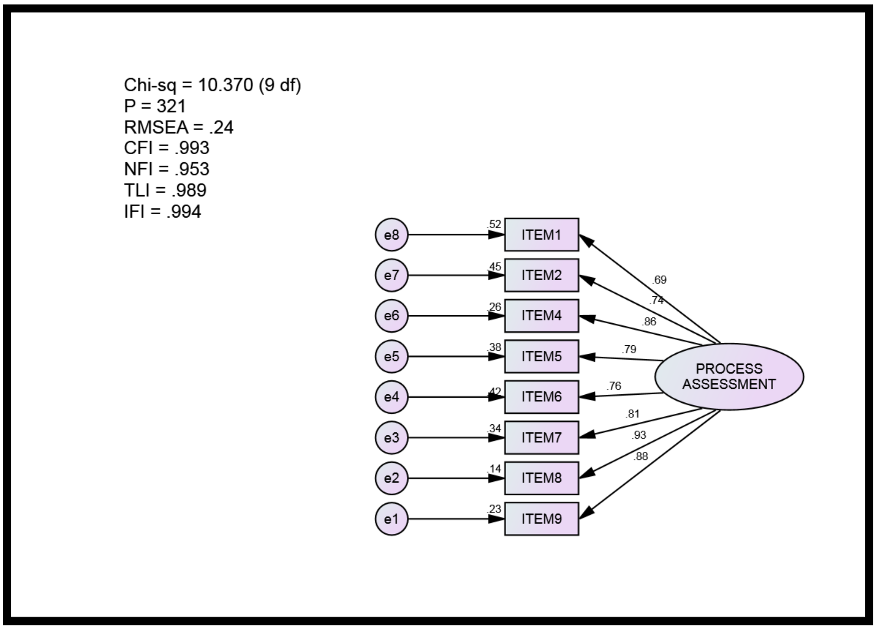

Figure 3. Revised model on process assessment techniques for assessing practical projects in mechanical technology

The revised model developed on Process Assessment Techniques for Assessing Practical Projects in Mechanical Technology had eight items with factor loadings ranging from .74 to .93. The Chi-square = 10.370, df = 9, P = .321, the ratio of the Chi-square and the df (< 3) = 1.15, NFI = .953 (> .90), CFI = .993 (> .90), IFI = .994 (> .90), TLI = .989 (> .90) and RMSEA = .24 (< .080).

Table 2. Factor loadings for process assessment techniques for assessing practical projects in mechanical technology

CODE	**Item Statements**	**Initial Model**		**Revised Model**		**Validity/ Reliability**	
		Factor Loading	**Error Variance**	**Factor Loading**	**Error Variance**	**CR**	**AVE**
	Process Assessment Techniques						
ITEM1	Selection of Correct Materials	.62	.39	.69	.52		
ITEM2	Selection of Appropriate Tools.	.55	.44	.74	.45	**0.94**	**0.66**
ITEM3	Selection of Safety Wears	.22	.07	Deleted			
ITEM4	Taking Accurate Measurement	.87	.57	.86	.26		
ITEM5	Taking Accurate Marking Out	.47	.22	.79	.38		
ITEM6	Taking Accurate Cutting of Materials	.73	.47	.76	.42		
ITEM7	Application of Different Bench and Machine Operations	.78	.52	.81	.34		
ITEM8	Observation of Safety Rules	.56	.66	.93	.14		
ITEM9	Appearance/Finished Product	.46	.74	.88	.23		

The initial factor loadings of the Process Assessment Techniques for Assessing Practical Projects in Mechanical Technology had initial factor loadings of nine items ranging from .22 to .87. While the revised factor loadings had eight items with factor loadings ranging from .69 to .93. Each factor loading is above the cut-off of 0.5 showing that all were Process Assessment Techniques for Assessing Practical Projects in Mechanical Technology. The Composite Reliability (CR) of Process Assessment Techniques for Assessing Practical Projects in Mechanical Technology is 0.94, while the Average Variance Extracted (AVE) is 0.66

4.2 Discussion

The proposed Process Assessment Model (See Figure 4) for Assessing Practical Projects in Mechanical Technology is presented below based on the CFA which trimmed the initial model of nine constructs to eight. It is then envisaged that observation of safety rules is all encompassing to have catered for selection of safety wears which was trimmed in the revised model. The findings as supported by Waskitoa et al. (2020), Lemo and Olakotan (2016) noted that practical projects are the nucleus of skill acquisition in VTE programs without which no meaningful skills can be acquired if practical activities do not support theoretical contents in VTE programs. The positions of Isa et al. (2019) also buttressed the study's findings as the scholars noted that students will not be able to relate theory with practice where practical experience is lacking. Additionally, in consonance with the findings of the study is the position of Krivikas (2005) in the Edgar Dale's cone of experience as the importance of practical projects are exposed towards achieving effectiveness in active engagement in practical activities. In the same vein, Damon et al. (2008) and Mohamad et al. (2017) were all in agreement that a well marshaled practical class which utilizes various strategies would develop students' skills.

Figure 4. Process assessment model

4. Conclusion

The process assessment model for assessing practical projects in mechanical technology developed using confirmatory factor analysis has achieved all criteria for construct, convergent and the discriminant validity. Based on the findings of the study, the study recommended the adoption of the model in assessing practical projects in mechanical technology and other related areas in vocational and technical education.

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