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Conceptual Model for Learning Automobile Transmission Systems A Case Study: Gearbox

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Abstract
Conceptual model represents a system that consist of concepts which are used to help students know, understand, or stimulates a subject the model represents. This article developed a conceptual model for learning gearbox as an Automobile Transmission System (ATS) for tertiary institutions offering Automobile Engineering (AE) courses. The model was developed based on the areas considered important on the gearbox denoted as (Gbx1 to Gbx7) areas. It relied exclusively on the Concept Maps (CMaps) assessment test and Structured Questionnaire (SQ) instruments developed by the researcher that were believed suitable for AE achievements. Six Gbx areas that were considered important for the article areGbx1 (working principles of gears), Gbx2 (gear system arrangement), Gbx3 (servicing of gear systems), Gbx4 (parallel and non-intersection shafts), Gbx5 (main and counter shafts functions), and Gbx7 (alignment of meshing gears) after using Structural Equation Modelling (SEM) analysis via modification through Analysis of Moment of structure (AMOS). The findings of the students' academic performance after introducing the model for instruction improved through the areas that were considered most important of the Gbx areas, which was further illustrated clearly, in a pictorial form.

Keywords: Conceptual Model, Learning, Gearbox, Transmission Systems, Concept Maps, Structured Questionnaire.

1.0 Introduction

Experimental learning practices have proven to be very important in Automobile Engineering (AE) from its emergence to date. Learning by doing is facilitated through a successful experimental learning practice, guided by instructional medium, which is full of learner-centred activities that have direct association with the learner's intellectual development that is the major focus of AE. This may suggest why employers of labour are in dare needs of graduates from tertiary institutions who are well equipped to function effectively in contributing to the development of the society.

Therefore, gearbox as a concept in this context refers to the transmission system used for the instruction. Today, the world has been transformed into economy nations. This is why employers of labour need graduates from institutions that are well equipped to function effectively for the development of the work force. This considerable shift has posed serious challenges to educational institutions. Well-informed based economy workforce implies and requires sound preparation of higher education students to work. In addition, tertiary institutions must reinforce personal and social responsibility inside and outside of institutions and simultaneously seek opportunity for students to participate in educational activities that is relevant in the changing world (Lungu *et al.*, 2012). It is therefore, agreed that it is the capacity and ability of the higher institutions to generate and transform new ideas, methods and products that can change these into monetary value or wealth.

Evidence with this development, AE at the forefront of economic, social and technological development must strive to provide viable opportunities to change the structural systems of teaching and learning. This will prepare the students to enter into a competitive global workforce. It is because students' academic and skill achievements have always been argued upon among the educators and researchers in order to meet the learning conditions of this preparation (Nasri and El-Shaarawi, 2006).

2.0 Material Methods

Structural Equation Modelling (SEM) as a technique via Analysis of Moment of Structure (AMOS) was specifically used to analyse the initial and modified measurement models of the Gbx items. During the analyses, jointly the number of factors and their indicators were explicitly specified as described by Kline (2005). The purpose of AMOS was also to determine the factor structure within a measurement model and to confirm how well the model fits the data according to Bollen (1989). Several researchers have provided established procedure on the proposed sequence of steps for SEM via AMOS. The model evaluation started with an evaluation of parameter estimates, such as square multiple correlations (R^2), followed by the examination of model fit as described by Joreskog and Sorbom (1996). When the model fit was poor, various diagnostic indicators such as standardized residuals, regression weights, and the modification indices according to Koufteros (1998) were properly determined. According to the schola, most standardized residuals should be less than 2.0 in absolute value for correlation models. Besides, other indicators also affected the fit performance of the proposed model. This included multivariate normal distribution and covariances. Multivariate normality of all observed variables was standard distribution assumptions in the SEM. A sample was considered to be multivariate when normality distributed at 0.05 level of significance and the critical ratio was smaller than 1.96, indicating that the coefficient of multivariate kurtosis was not significantly different from zero according to Mardia (1970). However, the multivariate Kurtosis can be large and multivariate non-normality can be extreme (critical ratio >1.96) even if univariate skewness and/or Kurtosis range between (-1.00 to +1.00) recommended by Muthen and Kalpan (1985) was obtained from most of variables in data. Based on the value of critical ratio of 1.96, some multivariate might be included in the sample, and therefore, should not be used as the standard value (Gao *et al*., 2007; and Kline, 2005). Therefore, modified measurement model, which complied and fit well to the data based on the default indices were considered as an appropriate answer for specific research question.

2.1 Brief Description of the Study Area

This article was produced based on the data obtained from the North-East geopolitical zone of Nigeria. The zone comprised of six (6) states namely: Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe States. It was produced based on the data collected in only three states of the region, particularly in the institutions that are offering AE (Table 1).

Table 1: List of selected Federal Universities offering AE in the North-Eastern Nigeria

Abbreviation	Name of institution	Location
ATBU	Abubakar Tafawa Balewa University, Bauchi	Bauchi State
FUTY	Federal University of Technology, Yola	Adamawa State
UNIMAID	University of Maiduguri, Maiduguri	Borno State

Table 2 presents the designed questionnaire to assess the students' academic performance at B. Engine. and B. Tech. Engine. levels in automobile transmission systems (ATS) on the concepts of gearbox, while same students constructed concept maps as presented in Figure 1 of ATS using randomly arranged gearbox items.

Table 2: What do you understand about automobile transmission systems?

S/No	ATS Concepts	Items/Areas
1		Driven gears
2		Driving gears
3		Spur gears
4		Helical gears
5	Gearbox	Connect
6		Parallel shafts
7		Non-intersection shafts
8		Example
9		Examples
10		Connect

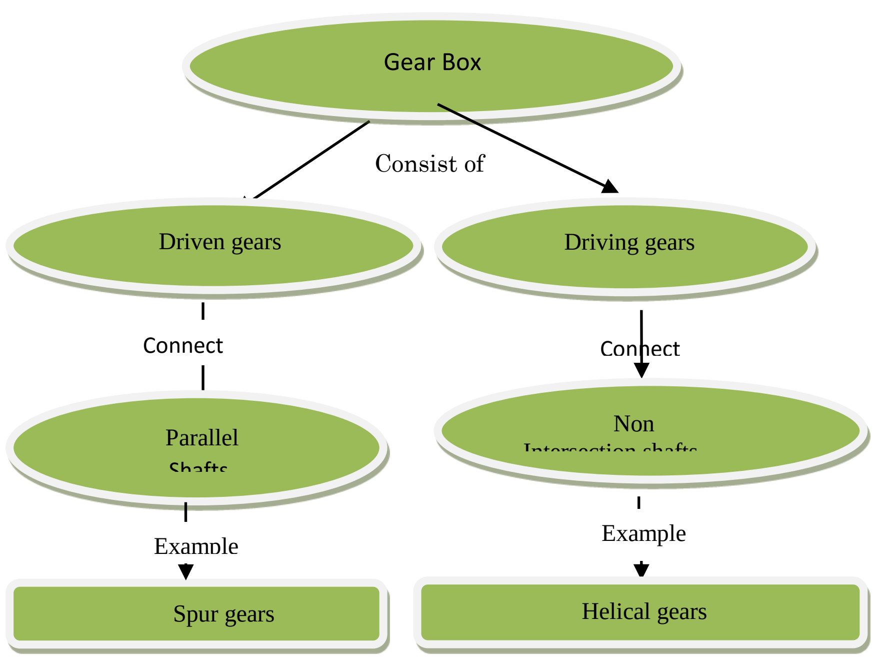

Fig. 1: CMAT Structure of Automobile Transmission Systems

Table 3 presents the summary of the eight areas considered important of gearbox. The model presents eight observed areas such as; working principles of gears, gear system arrangement, servicing of gears system, parallel and non-intersection shafts, main and counter shafts functions, driven/driving gears functions, alignment of meshing gears, and auxiliary gear systems with the corresponding R-square (regression index) of 973, 981, 984, 986, 986, 987, 987 and .988 respectively. These areas were considered important on gearbox after instruction on AE students.

The correlation coefficients (R) are presented in descending order starting from the observed areas that were considerably most important. The observed areas are presented in Table 3 following the order of the significant coefficients. The correlation coefficients indicated linear relationships between the eight observed areas. The highest value of Adjusted R^2 of .987 in Table 3 indicates that, the model account for 98.7% variance in the areas considered most important for developing gearbox model.

Table 3: SEM model summary of important areas of gearbox

	Areas Considered on Gearbox	R	R^2	Adjusted R^2	Std. Error
1	Gear system arrangement	.987[a]	.973	.973	.625
2	Working principles of gears	.991[c]	.981	.981	.525
3	Servicing of gears system	.992[d]	.984	.984	.481
4	Parallel and non-intersection shaft	.993[e]	.986	.985	.462
5	The main and counter shafts functions	.993[f]	.986	.986	.451
6	Driven and driving gears systems	.993[g]	.987	.987	.442
7	Alignment of meshing gears	.994[h]	.987	.987	.436
8	Auxiliary gears systems	.994[i]	.988	.987	.432

4.0 Result and Discussion

The findings discovered through the gearbox as an atopic after Stepwise Linear Regression (SLR) analyses were redressed through Structural Equation Modelling (SEM) via AMOS for the model development. This was because all the findings focused on the research questions that targeted the objective for the model development. In addition, findings obtained from the research questions were all on gearbox as an automobile transmission system. However, the discussion on the gearbox topics submerged in the research question was to develop the conceptual model for learning automobile transmission systems in AE as an objective of the article. Table 4 presents the default model fit valuation parameter on which model development relies as specified by various researchers.

Table 4: Default model fit evaluation indices (Kenny *et al.*, 2014)

Model Fit Indices	Range Values
Chi Square (χ^2)/df	< 0.30
Goodness of Fit (GFI)	≥ 0.90
Incremental Fit Index (IFI)	≥ 0.90
Tucker-Lewis Index (TLI)	≥ 0.90
Comparative Fit Index (CFI)	≥ 0.90
Root Mean Square Residual (RMSR)	≤ 0.05
Root Mean Square Error of Approximation (RMSEA)	≥ 0.05

Table 5 shows the computed values for model fit indices of the modified model for gearbox. Based on the result, the modified model satisfied Goodness of Fit (GOF) indices with 2.65 for (χ^2)/df, GFI (0.95), TLI (0.91), CFI (0.93), IFI (0.94), RMR (0.02) and RMSEA (0.04) at $P < .05$ as specified in the table.

Table 5: Modified measurement model fit indices of gearbox

Model Fit Indices	Computed values	Range Values	P
Chi-square (χ^2)/df	2.65	< 3.00	
Goodness of Fit (GFI)	0.95	≥ 0.90	
Tucker-Lewis Index (TLI)	0.91	≥ 0.90	
Comparative Fit Index (CFI)	0.93	≥ 0.90	.000
Incremental Fit Index (IFI)	0.94	≥ 0.90	
Root Mean Square Residual (RMR)	0.02	≤ 0.05	
Root Mean Square Error of Approximation (RMSEA)	0.04	≤ 0.05	

Table 6 shows the assessment of univariate normality distribution of the modified measurement model of Gearbox in AE. The skewness and kurtosis of the six observed factors variables are between the ranges of -1 and +1. This has supported the application of the observed factors for developing gearbox model for teaching AE courses.

Table 6: Normality of the modified measurement model of gearbox for teaching

Variable	min	max	skew	c.r.	kurtosis	c.r.
GBX7	1.000	5.000	-.647	-3.879	-.751	-.252
GBX5	1.000	5.000	-.851	-5.105	-.183	-.349
GBX4	1.000	5.000	-.395	-8.369	-.507	-.522
GBX3	1.000	5.000	-.835	-5.011	-.879	-.638
GBX2	1.000	5.000	-.555	-3.328	-.711	-.134
GBX1	1.000	5.000	-.538	-3.230	-.592	-.776
Multivariate					4.728	6.046

Figure 2 shows a structural model of the significant relationship between six areas considered most important on the topic of gearbox as a transmission system. Therefore, based on the modified model, it is concluded that for learning Gbx as a transmission system, the most important areas such as; Gbx1 (working principles of gears), Gbx2 (gear system arrangement) Gbx3 (servicing of gears system), Gbx4 (parallel and non-intersection shafts), Gbx5 (main and counter shafts functions), and Gbx7 (alignment of meshing gears) were considered most important in developing the model after introducing AMOS.

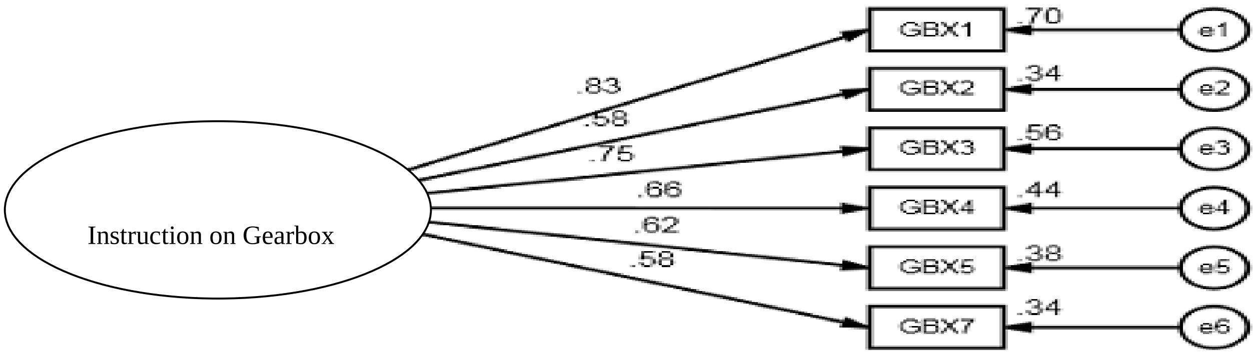

Fig. 2: Modified measurement model of gearbox

Based on the analysis of the data, after redressing the SEM through AMOS, Figure 3 was developed. The figure shows a conceptual model of the areas considered most important on the gearbox of the AE course. Shown in the figure, the areas of the findings are presented based on their level of importance. The triangular shape indicated by the arrow represents top-down hierarchy of the areas after instruction on the gearbox areas of AE course.

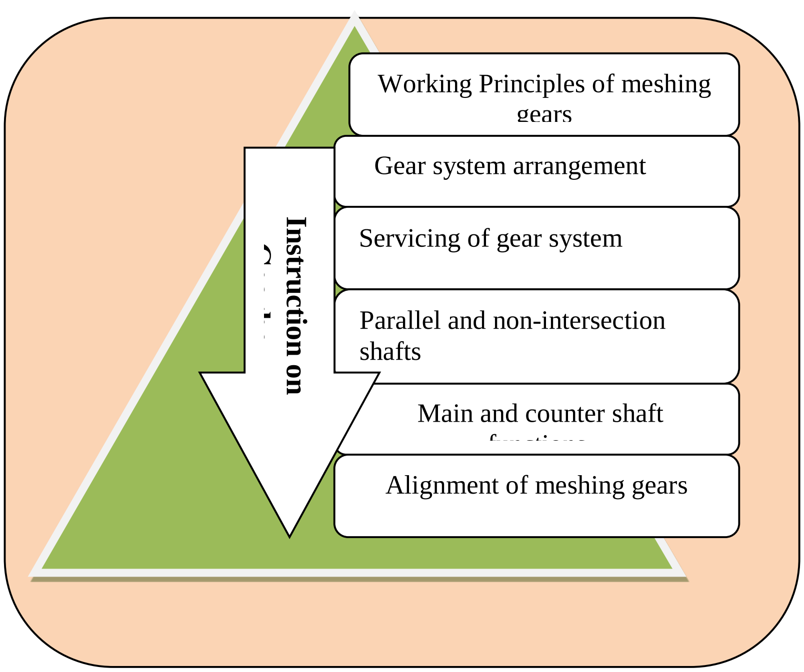

Fig. 3: Conceptual model for gearbox.

4.0 Conclusion

Quality education is an essential element for economic and social security of any nation (Babalola *et al.,* 2007), Nigeria is not an exception. If the motives of provision of excellence teaching and learning and research are to be actualized in the 21st[t]century, education in tertiary institutions, important transformation must be considered in such a way that education attend to real world practices through experimental learning using conceptual model for instruction. Concept mapping in engineering has proved to be a successful instructional approach for developing students' knowledge of understanding according to Acharya and Sinha (2015); Gurupur *et al.* (2015), through which data was collected.

Based on the identified areas of Gbx of the conceptual model, it implied that AE has direct benefits to its stakeholders (Faculty, students, community members, automobile engineering service agencies as well as tertiary institutions). These qualities of AE services were conceivably enunciated in many of the AE research studies. In this regard, the concluded results using the developed model for learning Gbx proved that students' academic performance and skill development improved. Therefore, the model could serve as a legitimate instrument for steering academic performance in tertiary institutions. Implementation of the model could serve in founding a strong and reliable AE practices in the Nigerian tertiary institutions for developing a holistic and skilled-minded AE graduates that are needed in the 21[st]century.

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