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Multi-temporal analysis of regression diagnostics for students' performance in property development and co-requisite courses

Ataguba Joseph Obaje*, Bioku Joseph Olufemi, Ogungbenro Matthew Taiwo
Department of Estate Management, The Federal Polytechnic Idah, P.M.B. 1037 Idah, Kogi State, Nigeria
*Email: josephtgb81@gmail.com

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ABSTRACT

Property development and other co-requisite courses have been embedded within academic programs in Estate Management. Among the objectives of this study include identifying the co-requisite courses that accounted for a variation in students' academic performance in property development, and to examine the characteristics of the diagnostics of ordinary least square (OLS) regression model for this relationship over time. Data for this study comprised 2007/2008 to 2014/2015 (8-year) scores for the 1st- and 2nd semester property development and its co-requisite courses in the Department of Estate Management of the Federal Polytechnic Idah, Nigeria. Tools of analysis comprised descriptive statistics (mean score, standard deviation, and coefficient of variation), fitted trend equations, multiple linear regression analysis, and a multi-temporal visualization of the regression diagnostics comprising *ZRESID vs. *ZPRED, normality tests for residuals, and the Durbin-Watson test. The variation in the scores for property development courses during the 8-year period was attributed to specific 1st - and 2nd semester co-requisite courses. EST311 (Valuation I) was found to be the most consistent regressor for EST313 (Property Development I) in the 1st semester, while EST325 (Estate Accounting), was the most consistent regressor for EST323 (Property Development II) in the 2nd semester. Multi-temporal diagnostics analyses did not provide any sufficient evidence to invalidate the OLS regression models for the 1st- and 2nd semester Property Development courses and their co-requisites. Stakeholders' commitment to the teaching and learning of the co-requisite courses was recommended as triggers for a sustained pass rate in the property development courses.

1. Introduction

From the perspective of products and services supply, property development encompasses series of processes including land acquisition, site assembly, estate design and planning, development of different types of properties, feasibility studies, arranging finance, construction, marketing and advertising, letting, sales, and provision of information (Harvey & Jowsey, 2004; Isaac et al., 2010; Magalhães, 2002; Wyatt, 2007). Products in this context include the physical or material change in land use, which attracts demand in the property market, while services are logistics offered in support of the physical or material change in land use. Property development is a vocation within the surveying discipline which affords practitioners the opportunity to offer service(s) in specific areas of land assembly, arranging finance, feasibility and viability studies, project management, and construction. The prior knowledge of these services as well as products (types of property development projects) is acquired in the course of education and training.

In most commonwealth British colonies, the education component of property development rests within the built environment such that some undergraduate and postgraduate programmes within the Faculty of the built environment lead to the conferment of specialist degrees in "Property Development" or "Real Estate Development". With specific reference to Nigeria, formal training in property development is embedded within the curriculum of academic programmes leading to the award of degrees or Diplomas in Estate Management. Within the context of polytechnic education, Estate Management students in the 2 -year National Diploma class must enrol for a course tagged "Introduction to Property Development", which is a primer to "Property Development I" and "Property Development II" offered in the 1st year of the Higher National Diploma (HND I) class. Irrespective of whether students are enrolled for a degree or HND, they offer property development along with specific co-requisites targeted at enhancing their understanding of the process, products, and services associated with property development. These courses are subsequently graded and the cumulative performance of students are documented to foster their graduation upon completion of all the course requirements.

A ballpark observation of the 2007/2008 to 2014/2015 results of the first year Higher National Diploma students of Estate Management programme at the Federal Polytechnic Idah, Nigeria indicates that the total score for each student in the 1st and 2nd semester property

development courses varied partly with performance in co-requisite courses. However, there has been no empirical study to substantiate this ballpark assessment which is likely to have a national impact on the training of Estate Management students in Nigeria. Hence, the following research questions have been put forward: (1) What 1st semester co-requisite courses explained students' performance in EST313 for each session? (2) What 2nd semester co-requisite courses explained students' performance in EST323 for each session? (3) What are the observable changes in the yearly regression diagnostics involving 1st semester observations of property development (EST313) and its co-requisite courses? (4) What are the observable changes in the yearly regression diagnostics involving 2nd semester observations of property development (EST323) and its co-requisite courses?

With respect to Estate Management (general practice surveying), Egbenta (2012) underscored the rationale behind the teaching and learning of cognate subjects. In consonance with this thought, the performance of students in property development courses is envisaged to depend on the quality of performance in the relevant co-requisite courses.

The thematic scope of this research is the analysis of time-varying regression and regression diagnostics involving property development courses and their co-requisites offered during the 1st and 2nd semesters of the 2007/2008- to the 2014/2015 academic sessions. The unit of analysis for this study is the HND I Estate Management class of the Federal Polytechnic, Idah in Nigeria. Besides the ease of access to data, the choice of undergraduates in HND I class was informed by the availability and consistency of data pertaining to scores they had earned in property development and co-requisite courses for the 8-year period under review.

The value of this research is anchored on the need for lecturers and academic counsellors to appreciate how students' understanding of the co-requisites have influenced the variation in the scores they have earned after attempting continuous assessment and examinations in property development. Furthermore, it is expected that this research would avail lecturers and academic advisers with a framework for counselling students towards comprehending property development studies using a system of properly coordinated study of its co-requisites. In the long run, it is hoped that this research would be beneficial to students and practitioners in the field of estate surveying and valuation; property development and investment companies intending to organize in-house staff training; and curriculum developers who intend (re-)designing programme content to align with changes in this body of knowledge.

2. Theoretical framework

2.1 The study of property development within the framework of the built environment

Development is statutorily defined as the physical transformation of land through building, engineering, and mining operations ("The Nigerian Urban and Regional Planning Act, CAP. N138 LFN," 2004). When development is targeted at an interest in landed property, it can be christened as "property development". Property development is among the courses offered in partial fulfilment for the award of a degree or diploma in Estate Management. The cognate disciplines (body of knowledge) that facilitates the teaching and learning of property development comprises Architecture, Geoinformatics and Surveying, Building Technology, Urban and Regional Planning, and Quantity Surveying. At the Federal Polytechnic Idah (the study area), Higher National Diploma (HND) programme in Estate Management is a 2-Year academic programme which grants the graduate the access to middle- and higher cadre of skills for the built environment and construction industry. Complementing the education of students at this level include courses in the aforementioned cognate disciplines, Civil Engineering, and Electrical/Electronic Engineering. Therefore, the exposure of Estate Management students to these allied disciplines is what accords property development its blend of applied knowledge of the built environment.

2.2 Property development and its co-requisite courses

Within the context of Nigerian Universities, there are variations in the nomenclature for "Property development" being a course offered as pre-requisite for the award of degree in Estate Management, among which include "Economics of Planned Development", "Estate Development" and "(Real) Estate Development". However, Nigerian polytechnics adopt "Property Development" as a unified name for the course (NBTE, 2002).

Students undergoing HND programme in estate management are trained to command a measure of competence in property development among other potential areas of real estate practice. In consonance with the HND curricula for Estate Management, students offer Property Development I (EST313) in the 1st semester with a view to providing them with intensive knowledge and techniques applicable to property development; while in the 2nd semester, they offer Property Development II (EST323), which is aimed at consolidating the knowledge of property development and its application to housing policies of the Federal and State governments (NBTE, 2002).

Within the context of this study, co-requisites are courses designed to integrate an array of skills required for property development practice. In addition to EST313 and EST323, the HND student enrols for compulsory co-requisites. Co-requisites offered in conjunction with EST313 in the 1st semester include BLD301 - Building construction III; URP128 - Urban planning principles and techniques; EST311 - Valuation I; EST314 - Land Economics I; EST315- Building Economics; and EST317 - Environmental and estate services. Co-requisites offered in conjunction with EST323 in the 2nd semester include BLD302 - Building Construction IV; URP406 - Environmental Impact Analysis; EST321 - Valuation II; EST322 - Property Law II;

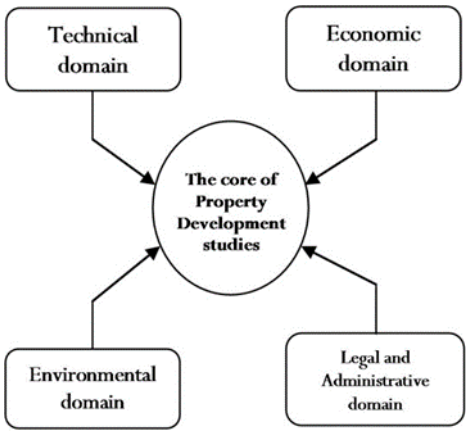


Figure 1: *The various domains of property development studies*

EST324 - Land Economics II; EST325 - Estate Accounting; and EST327 - Estate Services. Notwithstanding, other co-requisites were excluded from these lists because of the emphasis this study had placed on the contribution from disciplines in the built environment.

Co-requisites of Property Development can be classified into four domains comprising Legal and Administrative-, Technical-, Economic-, and Environmental domains (Figure 1).

It can be analyzed from Figure 1 that the co-requisites of property development that constitute the Legal and Administrative domains include Property Law (EST322) and Estate Accounting (EST325). The technical domain to the core of property development studies comprises Building Construction (BLD301 and BLD302), and Building Economics (EST315). Embedded in the economic domain include Valuation (EST311 and EST321) and Land Economics (EST314 and EST324), while the Environmental domain comprises Estate and Environmental services (EST317 and EST327), Environmental Impact Analysis (URP406), and Urban Planning Principles and Techniques (URP128).

2.3 Approved teaching style and learning resources

Pedagogies are teaching methods that would likely foster student-teacher interaction with a positive impact of knowledge transfer and retention. Just like other property-related courses, pedagogies that have been utilized over the years for EST313 and EST323 include lecture-based instruction, group work and collaboration, and field trips to relevant organizations where students can experience the practical applications of classroom activities (Ali & Alias, 2006). Prior to the delivery of lectures, the lecturer avails students with the recommended course readers. The delivery of lectures basically entails 2 hours of interactive session between the lecturer and students. While in attendance, students take down notes and listen to explanations offered by the course lecturer; in return, the lecturer requests students to narrate their personal experience of certain topical issues. Team work and independent study skills of students are strengthened through the administration of group- and individual assignments that are due for submission at a stipulated date and time. These assignments are graded and count towards the final course assessment. The prevalence of construction projects on campus further avails students the opportunity to experience property development vis-á-vis the practical manifestation of the co-requisite courses they have studied, and the contributions of allied professionals to the scheme.

2.4 Course assessment and grading

The import of assessment methods that encourage students to reflect on the outcome of their learning is most preferred in modern education practice (Postareff et al., 2007; Prosser & Trigwell, 1999; Trigwell et al., 1999). At the Federal Polytechnic Idah, the minimum pass mark for all courses including EST313 and EST323 and their co-requisites is put at 40% (comprising the sum of examination and continuous assessment scores). A student enrolled for these courses is expected to complete fieldwork exercises; and sit for tests and examinations. Although the minimum pass mark for courses is put at 40%, the ability of a student to accumulate scores of 50% and above implies a viable contribution towards graduating from the Estate Management programme within the bounds of at least lower- and upper credit classifications of the Higher National Diploma (HND). It is appreciated that this viable accumulation of at least 50 marks makes more sense when the student is able to reflect on the synergy between the quality of knowledge that has been amassed and the practical application of the same knowledge.

2.5 Learning outcomes

The learning outcome of property development is better understood from a wider economic perspective. In this context, property development has been instrumental to job creation, housing and infrastructure provision (D'Arcy & Keogh, 2002; Harvey & Jowsey, 2004), as well as consolidation of markets for lending facilities (Harvey & Jowsey, 2004). From the Nigerian perspective, Nuhu (2007) found that property development engenders increased wages for both skilled and unskilled labour engaged therein; and with corresponding multiplier effects of savings in rent, better productivity and increase in disposable income. Similarly, it has been observed that there is a correlation between gross domestic product (GDP) of a nation and the level of property development activities (Ball, 2002; Geltner et al., 2007; Ojetunde, 2013). Furthermore, the learning outcome for EST313/EST323 and their co-requisites is to build the capacity of students to become competent property development consultants, competent entrepreneurs in the real estate- and allied industry, job creators, and providers of housing and infrastructure that would help meet the needs of the government, firms and households.

2.6 Predictors of students' performance in real estate courses

There are studies that have successfully unravelled the determinants of academic performance in specific courses offered by students in pursuit of a degree/diploma. Allen and Carter (2007) categorized these determinants into intellectual and non-intellectual variables. Intellectual variables comprise scores for pre-admission tests, grades earned in specific courses, and skills assessment; while non-intellectual variables include demographic data, behavioural-, and personality traits (Allen & Carter, 2007).

Furthermore, tools used over the years to calibrate the relationship between grades earned in a specific course and a list of expected predictors include Ordinary Least Square (OLS), probit-, ordered-probit-, Tobit-, and Logistic regressions, and the Heckman's two stage technique (Allen & Carter, 2007; Chan et al., 1997; Didia & Hasnat, 1998; Gupta & Maksy, 2004; Huffman, 2011). In most of these related studies, a particular course is selected as the dependent variable while the explanatory variables (regressors) include these intellectual and/or non-intellectual variables depending on the research problem posed. For instance, Didia and Hasnat (1998) deployed OLS and ordered probit model and found the determinants of scores earned in Principles of Finance to include among other factors the cumulative grade point average CGPA, grades earned in pre-requisite courses, and the age of students. It is important to note that co-requisite courses are offered collectively in a given semester, while prerequisite courses are offered and passed as a condition for enrolling in the advanced or intermediate version of a given course. Given the emphasis of prerequisite courses, Didia and Hasnat (1998) did not explicitly address the correlation between the dependent variable (Principles of Finance) and scores earned in co-requisite courses.

Chan et al. (1997) utilized a combination of Tobit model and the Heckman's two-stage technique and found the significant determinants of grades in principles of finance to include class attendance and choice of finance major (using the Tobit model); while choice of finance major and CGPA were found to be significant predictors of grades earned in the same principles of finance (using the Heckman's approach).

Among all similar studies of the intellectual and non-intellectual predictors of course scores, OLS and probit models dominate the

model calibration technique as against Tobit and the Heckman's approach (Allen & Carter, 2007; Johnson et al., 2002). Nonetheless, in a study to answer the question of predictors of academic success of students enrolled in real estate programs, Allen and Carter (2007) deployed a truncated regression technique and found that the grades earned in the core courses are significant predictors of the overall performance of students. Their application of the truncated regression technique was due to the incomplete data arising from the withdrawal of some students prior to the completion of the programme.

In a similar study, Huffman (2011) used the ordered-probit regression and found the factors that explain variation in students performance in real estate finance and investment course to include CGPA, choice of real estate majors, class size, proportion of the male gender, and the class level (academic maturity of the student). Contrary to Allen and Carter (2007), Huffman (2011) had shown that an interaction between intellectual and non-intellectual variables can influence students' performance in real estate courses.

Commenting on the results of Chan et al. (1997) and Huffman (2011), the identification of CGPA as a predictor of student's performance in real estate courses does not accord any significant contribution to knowledge given the fact that the grades in these real estate courses would have been embedded in the calculation of the CGPA used as the regressor. A notable feature of these previous studies is the identification of predictors of overall performance of students without regard to an observation of session-to-session or semester-to-semester variation in model fit arising from the use of any of OLS, probit, ordered-Probit, Tobit, logistic regression and the Heckman's two stage technique. For the purpose of this current study, the co-requisite courses that predict the scores earned in Property Development for the first and second semesters were examined using OLS regression analysis for a given semester and on a session-by-session basis.

2.7 Trend analysis of students' academic performance

One of the notable weakness of previous studies that sought to evaluate the determinants of the academic performance in specific courses offered by students in pursuit of a degree/diploma is the generalization of findings based on a snapshot analysis of data as against examining periodic changes in these determinants. In other words, a robust study should account for the fact that the covariates of a particular course performance might exhibit unstable behaviour over time.

There is a dearth of literature addressing trend analysis of average scores earned by real estate students across domain and ancillary courses, and within a specific institution of higher learning. To this end, an attempt was made to review available studies that address similar phenomenon especially on a course-by-course and country-to-country basis. Grissmer (2000) argued that the publication of time series of average scores in the Scholastic Aptitude Test (SAT) taken by students across schools and geographic areas is not in the best interest of the public on the ground that these trends might be biased and subject to gross misinterpretation. Unlike the inability of time series analysis of average scores to adequately reflect the characteristics of voluntary test takers (Grissmer, 2000), such an analysis might serve as an internal evaluation tool for the study habit and competence of students admitted into a degree or diploma programme offered at a higher education institution.

In a study analyzing the variation in teacher licensure test (Praxis II) scores from the years 1999 to 2006, Gitomer and Qi (2010) deployed descriptive statistics (mean, median, and standard deviation), frequency distribution, trend analysis of mean test scores, and OLS regression. Among their results include minimal changes in the mean test scores, a higher pass rate among candidates who sat for the test and a variation in the trend of scores across the nine courses being examined.

Angrist et al. (2013) attempted a peer-review mechanism of countries around the world on the basis of students' performance in public exams involving mathematics, reading, and science. They used adjusted test scores for the purpose of international comparability, graphed the time series of the adjusted mean scores, harnessed dataset on governance indicators likely to exert impact on the quality of human capital and educational institutions, and analyzed these datasets using OLS regression technique. They found that economic freedom and democracy were the significant determinants of students' academic success in developing countries, while a cursory observation of country -by-country data indicates a general decline in the aggregate pass rate of students across these subjects.

In a related study of benchmarking students' performance, Goldstein and Leckie (2016) used a combination of trend analysis and multilevel regression to compare General Certificate of Secondary Education (GCSE) grade score across four examination boards from 2007 to 2011. The study found that Welsh pupils who attempted GCSE during the period under review did not perform better than their peers in England. In consonance with Rogers and Yang (1996), Goldstein and Leckie (2016) attributed this trend to the lacklustre attitude of Welsh pupils towards GCSE preparedness.

Insights from a review of these studies were adopted and modified towards trend analysis for course-by-course comparison of students' performance from 2007/2008 to 2014/2015. In addition to OLS modelling, this study draws its strength from the comparison of the significant predictors and regression diagnostics involving first- and second semester property development courses and their co-requisites over a long period (8-year period) contrary to the OLS regression analysis of a single-period data.

3. Methodology

3.1 Data type and data specification

For the 8-year period under review (2007/2008 to 2014/2015 academic sessions), analysis of the first- and second semester co-

Table 1: *1st semester data type and specification*

Course code	Course title	Measure-ment scale for scores	Expected impact of variable
Dependent variable			
EST313	Property Development I	Ratio	+
Explanatory variables			
BLD301	Building Construction III	Ratio	+
URP128	Urban planning principles and techniques	Ratio	+
EST311	Valuation I	Ratio	+
EST314	Land Economics I	Ratio	+
EST315	Building Economics	Ratio	+
EST317	Environmental and estate services	Ratio	+

Table 2: *2nd semester data type and specification*

Course code	Course title	Measurement scale for scores	Expected impact of variable
Dependent variable			
EST323	Property Development II	Ratio	+
Explanatory variables			
BLD302	Building Construction IV	Ratio	+
URP406	Environmental Impact Analysis	Ratio	+
EST321	Valuation II	Ratio	+
EST322	Property Law II	Ratio	+
EST324	Land Economics II	Ratio	+
EST325	Estate Accounting	Ratio	+
EST327	Estate services	Ratio	+

requisites of property development scores have been treated separately. For the 1st semester of each session, EST313 (Property development I) was the dependent variable, while the co-requisites comprising BLD301, URP128, EST311, EST314, EST315, and EST317 were set as the explanatory variables (Table 1).

For the 2nd semester of each session, EST323 (Property development II) was the dependent variable, while its predictors comprise BLD302, URP406, EST321, EST322, EST324, EST325, and EST327 (Table 2).

All the dependent variables and their predictors were expected to exhibit positive coefficient in the OLS regression notwithstanding the possible variation in the values of these coefficients.

3.2 Sampling

This study adopts a census survey of all students in the first year of HND programme in Estate Management from the 2007/2008 to the 2014/2015 academic sessions (Table 3).

The rationale for the adoption of a census survey in this study is to reduce standard errors (Field, 2009), to avail the OLS regression analysis with larger samples that are representative of cases, and to cancel out errors of measurement (Singh, 2006). The 2nd semester total observations for the 8-year period would have been 478 save for the voluntary withdrawal of a student in the 2nd semester of the 2007/2008 session, which had no significant impact on data analysis.

3.3 Data pre-processing and descriptive statistics

The first and second semester scores were cross-tabulated. The mean score and standard deviation were computed for annual observations of the 1st and 2nd semester explanatory- and dependent variables, while the coefficient of variation (Cv) was used to provide meaningful interpretation to the degree of variability of mean scores. Also computed were the mean score and standard deviation for the pooled (aggregate) 1st and 2nd semester explanatory- and dependent variables.

Prior to the multiple linear regression analysis, the annual mean scores for 1st and 2nd semester property development courses and their co-requisites were fitted with linear function (Equation 1) to aid ballpark comparison of the relative trends in the mean scores:

$$Y = a + bX' + \varepsilon \qquad (1)$$

where the score per annum in a course is a function of a constant term a, slope of the fitted trend line b, the year count X' (valued from 1 to 8), and an error term ε, which is assumed to be zero.

3.4 Stepwise backward regression analysis

The multiple linear regression model (OLS) used as a framework for determining the co-requisite courses that are regressors for the first and second semester property development courses is expressed as:

$$Y' = a + b_1X_1 + b_2X_2 + \ldots + b_nX_n + \varepsilon \qquad (2)$$

For Equation 2, Y' is the dependent variable, which symbolizes EST313 in the 1st semester, and EST323 in the 2nd semester. "a" symbolizes the constant term in the model, while b1 to bn represents coefficient of the regressors comprising X1 to Xn. As recommended by scholars (Field, 2009), an error term ε, assumed to be normally distributed and having a zero mean and standard deviation, was introduced into Equation 2 to account for a difference between the predicted and the observed value of Y' for each observation.

The backward elimination technique of linear regression modelling was deployed within the SPSS Version 21.0 environment. Associated with each annual model of students' performance in property development and its co-requisites for the first and second semester are the constant term, coefficients of linear regression, and p-values of regressors. Only regressors with p-value of at least 0.10 were reported as determinants of performance in EST313 and EST323 respectively. Besides the year-to-year model of 1st and 2nd semester performances in the property

Table 3: *Census count of first year HND students for the 1st and 2nd Semesters*

	Observations per session							
Semester	2007/2008	2008/2009	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015
1st	60	62	62	56	63	62	65	48
2nd	59	62	62	56	63	62	65	48

Sum of the 1st semester observations, $n_1 = 478$; sum of the 2nd semester observations, $n_2 = 477$

development courses, a model of pooled observations for the 1st and 2nd semesters was calibrated to provide an overall assessment of the impact of the explanatory variables. Other results of the regression analysis include the coefficient of multiple correlation, R; adjusted coefficient of multiple determination, (adjusted R-Square); and an acceptable p-value for the ensuing model which is hypothesized at $p < 0.05$.

3.5 Regression diagnostics

The multi-temporal comparison of regression diagnostics was instantiated using Variance inflation factor (VIF) for model coefficients, scatter plot of *ZRESID vs. *ZPRED, normal plot of *ZRESID, P - P Plot, Jarque-Bera statistic, and the Durbin-Watson dw test. These diagnostic tests were used to assess additive property and collinearity of scores in co-requisite courses (VIF), homoscedasticity of regression model (*ZRESID vs. *ZPRED), normality of residuals in the regression models for the 8-year period (normal plot of *ZRESID, P–P Plot, and Jarque-Bera statistic) and, test for serial correlation (autocorrelation) in residuals of the multiple regression models of scores earned by students in EST313/EST323 and their co-requisites for the 1st and 2nd semesters of the 8-year period (Durbin-Watson test).

4. Results and Discussion

4.1 Trend analysis of average scores for Property Development and co-requisite courses

Table 4 indicates the trend in the mean and standard deviations of scores for EST313 and its co-requisites over the 8-year period. It was observed that students performed better in EST311 (Valuation I) which is quantitatively inclined in course content compared to EST313 (Property Development I). Furthermore, students performed better in BLD301, EST314, and EST317 compared to EST313. It was observed that the mean score of students in EST313 and its co-requisites were generally above 50% in 2013/2014 and 2014/2015 save for URP128 which recorded a mean score of 49.42% in 2014/2015. Compared to other covariates, EST317 recorded a low degree of variability in mean scores from 2009/2010 (0.155) to 2011/2012 (0.106). However, a high coefficient of variability in mean scores were observed against EST313 for the 2007/2008-, 2009/2010-, 2011/2012-, and 2014/2015 sessions; EST315 (2008/2009 and 2012/2013); EST314 (2010/2011) and EST311 (2013/2014). All covariates of EST313 attained pooled average of at least 50% (Table 4). This result implies that the OLS-predicted score for EST313 (Property Development I) over the 8-year period would not deviate significantly from nearly 50% for an average student who scored approximately 57% in BLD301 and URP128; 51% in EST311; 54% in EST314 and EST315; and 56% in EST317.

The trend equations in Table 4 further provided ballpark assessment of co-requisite courses that might have influenced students' learning and performance in the 1st semester property development courses for the 8-year period. These equations were deployed in consonance with similar studies pertaining to variables that determine academic performance of students (Gitomer & Qi, 2010; Goldstein & Leckie, 2016). Throughout the 1st semesters of the 8-year period, EST313 exhibited a positive trend with a coefficient less than unity. Other regressors (covariates) with positive trends include BLD301, EST311, EST314, and EST315. Compared to EST313, URP128 and EST317 recorded a decline in the average scores over the 8-year period.

Except for EST323 (Property Development II) that exhibited negative trend in the mean scores of students over the 8-year period, all its co-requisites exhibited a positive trend (Table 5). At least 59% was calculated as the pooled mean score for EST321, EST322, and EST324 respectively, while BLD302 and EST325 recorded a pooled mean score of at least 60%. Co-requisites with the lowest and highest variability in mean score include EST322 (C_v = 0.1774) and URP406 (C_v = 0.221) respectively. The OLS-predicted score for EST323 (Property Development II) over the 8-year period is envisaged to revolve around 54% for an average student who scored approximately 59% in EST321, EST322, and EST324; 60% and 61% in EST325 and BLD302 respectively; and 54% and 58% in URP406 and EST327 respectively.

4.2 OLS regression analysis

Results of the annual OLS regression for the 1st semester courses (Table 6) was deployed to answer the question regarding the co-requisites that explain variation in the scores for EST313 (Property Development I). Over the 8-year period, the 2007/2008 model indicated regressors that account for the least (25.3%) variation in

Table 4: *Yearly mean scores with (standard deviation of scores) for EST313 and its co-requisites*

Session	2007/ 2008	2008/ 2009	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	Pooled data	Fitted equation for trend in mean score	Comment on trend
Sample (N)	60	62	62	56	63	62	65	48	478		
EST313	46.85 (11.21)	53.74 (11.85)	46.42 (12.58)	54.32 (12.80)	46.48 (14.31)	44.87 (12.87)	53.12 (14.17)	53.02 (13.80)	49.73 (13.43)	$Y = 48.374 + 0.3286X$	Positive
BLD301	58.95 (9.35)	59.15 (8.99)	48.02 (8.85)	50.86 (12.69)	55.41 (11.09)	60.66 (8.63)	66.71 (8.17)	60.96 (7.48)	57.62 (11.04)	$Y = 52.536 + 1.1231X$	Positive
URP128	57.18 (11.69)	49.77 (10.81)	57.42 (12.99)	60.36 (12.34)	64.57 (8.96)	58.85 (10.98)	56.63 (10.22)	49.42 (11.95)	56.96 (12.12)	$Y = 57.392 - 0.1371X$	Negative
EST311	52.90 (8.80)	50.18 (13.71)	49.50 (12.70)	48.29 (13.01)	49.51 (13.10)	51.65 (12.89)	51.22 (15.89)	59.63 (14.52)	51.40 (13.46)	$Y = 48.397 + 0.714X$	Positive
EST314	59.05 (7.28)	47.85 (9.46)	50.06 (10.02)	42.70 (12.83)	69.71 (10.32)	58.16 (12.50)	53.35 (14.33)	50.73 (10.90)	54.20 (13.57)	$Y = 52.849 + 0.2449X$	Positive
EST315	56.38 (10.52)	39.82 (12.54)	51.42 (12.52)	52.98 (11.69)	65.52 (10.28)	49.24 (14.36)	52.62 (13.46)	62.46 (14.44)	53.57 (14.50)	$Y = 47.775 + 1.34X$	Positive
EST317	61.37 (9.66)	59.74 (10.35)	60.39 (9.34)	52.11 (4.47)	52.54 (5.58)	51.27 (8.66)	55.63 (9.14)	55.85 (7.89)	56.14 (9.16)	$Y = 60.726 - 1.0252X$	Negative

Table 5: *Yearly mean score with (standard deviation of scores) for EST323 and its co-requisites*

Session	2007/ 2008	2008/ 2009	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	Pooled data	Fitted equation for trend in mean score	Comment on trend
Sample (N)	59	62	62	56	63	62	65	48	477		
EST 323	56.78 (6.57)	49.26 (9.64)	55.85 (8.02)	56.91 (10.36)	56.56 (10.48)	56.03 (11.70)	56.52 (9.78)	50.56 (11.87)	54.91 (10.22)	$Y = 55.186 - 0.0835X$	Negative
BLD 302	59.63 (8.79)	58.94 (8.61)	53.97 (9.68)	57.13 (8.68)	57.33 (9.42)	62.00 (9.60)	71.00 (8.73)	71.42 (10.16)	61.25 (10.90)	$Y = 52.471 + 1.9899X$	Positive
URP 406	51.68 (11.05)	52.35 (10.78)	53.40 (11.80)	63.63 (9.97)	50.14 (12.31)	51.76 (12.24)	57.68 (12.14)	54.31 (10.20)	54.28 (12.02)	$Y = 52.942 + 0.3171X$	Positive
EST 321	56.58 (8.09)	57.40 (9.70)	59.61 (10.63)	55.86 (13.17)	64.27 (7.69)	57.21 (14.37)	63.09 (12.69)	62.06 (15.81)	59.53 (12.01)	$Y = 55.865 + 0.8101X$	Positive
EST 322	60.10 (8.76)	53.81 (7.71)	55.73 (9.72)	62.11 (10.17)	64.92 (9.06)	64.89 (10.95)	55.58 (9.88)	54.60 (10.39)	59.04 (10.48)	$Y = 58.929 + 0.0084X$	Positive
EST 324	62.66 (9.77)	51.82 (8.72)	60.02 (11.86)	59.89 (9.15)	62.38 (9.59)	51.24 (10.47)	67.42 (12.05)	58.29 (8.71)	59.27 (11.39)	$Y = 57.954 + 0.2803X$	Positive
EST 325	61.17 (6.59)	60.77 (9.64)	53.52 (8.55)	54.27 (10.66)	72.57 (12.12)	55.84 (11.31)	57.83 (8.88)	64.85 (11.19)	60.04 (11.57)	$Y = 58.156 + 0.4327X$	Positive
EST 327	55.93 (8.94)	54.18 (8.00)	50.15 (8.75)	66.71 (10.08)	66.05 (9.60)	55.81 (10.26)	57.29 (7.21)	61.27 (7.38)	58.26 (10.35)	$Y = 54.713 + 0.8245X$	Positive

scores for EST313 to include BLD301, URP128, and EST311. However, OLS regression for the 2011/2012 returned regressors accounting for the highest (74.7%) variation in the scores for EST313 to include EST311, EST314, EST315, and EST317.

The pooled OLS regression model (Pooled OLS 1) indicates that BLD301, URP128, EST311, and EST317 (all significant at $p < 0.01$) explained nearly 48% variation in scores that students have earned in EST313. The annual and pooled OLS regressions further indicate that EST311 (Valuation I) was relatively consistent as an explanatory variable of EST313 ($p < 0.01$). Although EST314 (Land Economics I) and EST315 (Building Economics) featured prominently as regressors for EST313 for 5-year period, they were not significant.

The annual OLS regression results for 2nd semester (Table 7) answers the question regarding the co-requisites that account for a variation in the scores for EST323 (Property Development II) over the 8-year period. In Table 7, the 2007/2008 OLS model contained regressors accounting for the least (38%) variation in scores for EST323 to include EST322, EST325, and EST327. Furthermore, 2012/2013 model contained regressors that accounted for the highest (78.3%) variation in the scores for EST323 to include BLD302, EST325, and EST327.

The pooled OLS model (Pooled OLS 2) indicates that BLD302 ($p < 0.05$), URP406, EST322, EST324, and EST325 (all significant at $p < 0.01$) explained nearly 54% variation in the performance of students in EST323 - Property Development II (Table 7). EST325 (Estate

Table 6: *Models for first semester regressors of EST 313 (Property Development I)*

	Model coefficient								
Predictors	2007/ 2008	2008/ 2009	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	Pooled OLS 1
Constant	-2.545	-9.621	-7.440	4.508	-56.544	-12.581	-16.524	3.877	-8.528
BLD 301	0.250*	0.329***				0.279*	0.311*		0.266***
URP 128	0.225**			0.252**			0.372**		0.195***
EST 311	0.412***	0.391***		0.531***	0.388***	0.321***	0.346***		0.399***
EST 314			0.662***	0.210**	0.375***	0.245*		0.548***	
EST 315			0.403***		0.250**	0.198*	0.192*	0.342***	
EST 317		0.407***			0.786***				0.202***
Observation	60	62	62	56	63	62	65	48	478
R	0.540	0.827	0.778	0.804	0.874	0.814	0.809	0.672	0.697
Adj- R^2	0.253	0.667	0.592	0.627	0.747	0.639	0.631	0.427	0.482
p-value (model)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

****Significant at $p < 0.01$; **Significant at $p < 0.05$; *Significant at $p < 0.10$*

Table 7: *Models for second semester regressors of EST 323 (Property Development II)*

	Model coefficient								
Predictors	2007/ 2008	2008/ 2009	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	Pooled OLS 2
Constant	15.459	-5.059	17.606	-3.538	-7.189	-12.930	6.544	-25.547	1.006
BLD 302		0.243**	0.303***		0.263***	0.472***		0.267*	0.098**
URP 406		0.404***	0.186**		0.195***		0.277***		0.215***
EST 321									
EST 322	0.298***	0.350***	0.215**	0.299***				0.277**	0.299***
EST 324					0.382***		0.197**	0.334**	0.186***
EST 325	0.241**			0.343***	0.208*	0.334***	0.359***	0.347***	0.126***
EST 327	0.155*			0.348***		0.378***			
Observation	59	62	62	56	63	62	65	48	477
R	0.642	0.780	0.750	0.765	0.873	0.891	0.746	0.738	0.739
Adj- R^2	0.380	0.588	0.541	0.562	0.747	0.783	0.535	0.502	0.541
p-value (model)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

****Significant at p < 0.01; **Significant at p < 0.05; *Significant at p < 0.10*

Accounting) was relatively consistent as a significant regressor of EST323. Also featuring as consistent regressors of EST323 are BLD302 (Building Construction IV) and EST322 (Property Law II). Results of statistical experimentation indicated that the inclusion of the erstwhile eliminated EST321 (Valuation II) in the pooled OLS model would make it a significant regressor of EST323 ($p < 0.05$).

Notwithstanding the variation in methodology and data selection, results in Tables 6 and 7 align with a similar study where the grades earned in core real estate courses were significant predictors of the overall performance of students (Allen & Carter, 2007). Contrary to similar studies pertaining to determinants of students academic performance (Chan et al., 1997; Didia & Hasnat, 1998; Huffman, 2011), this study did not incorporate the impact of non-intellectual variables like class attendance, age- and gender of students because the research problem placed more emphasis on intellectual variables.

All the OLS models in Tables 6 and 7 are significant ($p < 0.01$). Secondly, regressors of Property Development I and II respectively have been observed to have varied over the 8-year period and implies a likely variation in the values and patterns of the OLS regression diagnostics, which has been unravelled in the next section of this study.

4.3 Multi-temporal analysis of 1st semester OLS regression diagnostics

In Figure 2, results of the average variance inflation factor (VIF) for the regressors of EST313 over the 8-year period, and the VIF for significant regressors in the pooled OLS model (Pooled OLS 1) imply that these regressors exhibit reasonable additive attribute and are devoid of any significant collinearity.

The assumption of random errors was not violated following the general pattern of homoscedasticity observed from the visual inspection of the *ZRESID – *ZPRED plots for the annual and pooled OLS regression model of EST313 and its significant regressors (Figure 2). The normality of residuals for the 8-year pooled OLS model of EST313 and its co-requisites was validated with recourse to the normal plot of *ZRESID, P–P plot, and the Jarque–Bera tests ($p > 0.05$). While the normality of residuals for all the other year-to-year OLS models of EST313 were validated, the 2014/2015 OLS model failed the normality test. Furthermore, the Durbin Watson test affirmed the validation of independence of residuals for the year-to-year and pooled OLS regression models for EST313 and its regressors.

In summary, there was no significant change in the average year-to-year VIF of predictors to warrant their invalidation in the OLS models. Secondly, the 2007/2008 to 2014/2015 graphs of *ZRESID vs. *ZPRED are multi-temporal visualization of homoscedasticity. Thirdly, the normality of residuals for OLS models of EST313 and its co-requisites were validated for 7 out of the 8 years' period (2007/2008 to 2013/2014). Fourthly, the Durbin Watson diagnostic tests for the yearly OLS models are evidences of multi-temporal validation of the assumption of independence of residuals.

4.4 Multi-temporal analysis of 2nd semester OLS regression diagnostics

With respect to the VIF in Figure 3, the regressors of EST323 over the 8-year period, and the significant regressors in the pooled OLS model exhibit reasonable additive attribute and are devoid of any significant collinearity.

The assumption of random errors was not violated for OLS models in the range of 2007/2008 to 2010/2011 session and the 2012/2013 and 2014/2015 sessions following the general pattern of homoscedasticity observed in the *ZRESID – *ZPRED plots. However, the pooled OLS 2 model violated random error assumption (Figure 3).

The normal plot of *ZRESID, P–P plot, and the Jarque–Bera tests validated assumption of normality of residuals for the OLS models of EST323 and its co-requisites for all sessions ($p > 0.05$) except for the 2013/2014 session. The Jarque–Bera test invalidated the assumption of normality of residuals for the pooled OLS model for EST323 notwithstanding the visualization of the near convergence of observed residuals with the diagonal of the P–P plot. Statistical experimentation further indicated that the normality assumption for the pooled OLS model for EST323 was validated upon the removal of the 2013/2014 data ($p > 0.05$), implying that the violation of normality assumption for the pooled OLS model of EST323 is attributed to the 2013/2014 data.

In summary, there was no significant change in the average year-to-year VIF of predictors to warrant their invalidation in the OLS models for EST323 and its co-requisites. Secondly, the 2007/2008- to 2012/2013

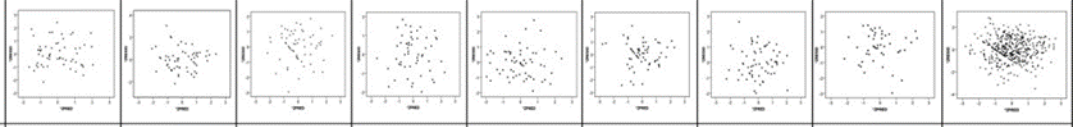
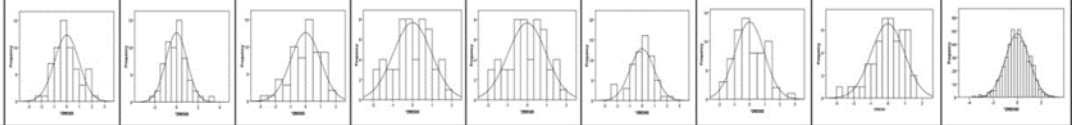
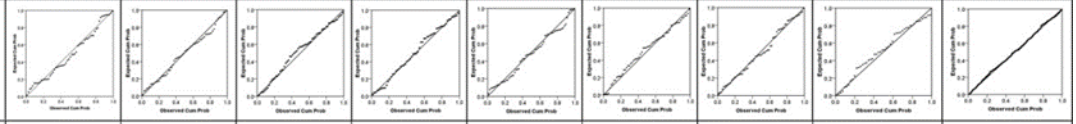
Diagnostic test		Results of 1st semester EST313 model diagnostic tests								
		2007/2008	2008/2009	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	Pooled OLS 1
VIF of Predictors	Constant	-	-	-	-	-	-	-	-	-
	BLD 301	1.103	1.197				1.507	1.397		1.295
	URP 128	1.063			1.292			2.117		1.251
	EST 311	1.127	1.404		1.396	1.565	2.181	1.548		1.449
	EST 314			1.184	1.306	1.477	2.545		1.240	
	EST 315			1.184		1.780	2.548	1.566	1.240	
	EST 317		1.610			1.584				1.224
Average (VIF)		1.098	1.404	1.184	1.331	1.602	2.195	1.693	1.240	1.305
*ZRESID vs *ZPRED										
Normal Plot of *ZRESID										
P - P Plot of standardized regression outcomes										
JB Test	Stat	2.345	3.096	4.496	2.397	3.949	3.315	0.456	6.859	4.378
	p-value	0.310	0.213	0.106	0.302	0.139	0.191	0.796	0.032	0.112
d_w	Stat	1.895	1.764	1.553	1.820	1.564	1.907	1.950	2.061	1.494
	~ *p*-value	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$
Remarks		Normality of residual Insignificant autocorrelation	Normality of residual Insignificant autocorrelation	Normality of residual Insignificant autocorrelation	Normality of residual Insignificant autocorrelation	Normality of residual Insignificant autocorrelation	Normality of residual Insignificant autocorrelation	Normality of residual Insignificant autocorrelation	Non-Normality of residual Insignificant autocorrelation	Normality of residual Insignificant autocorrelation

Figure 2: *Multi-temporal diagnostic tests for regression model of EST313 and its co-requisite courses*

-; and the 2014/2015 graphs of *ZRESID vs. *ZPRED are multi-temporal visualization of homoscedasticity except for the 2013/2014- and the pooled OLS 2 models. Thirdly, normality of residuals was affirmed for the 2007/2008- to 2012/2013-; and the 2014/2015 OLS models of EST323 and its co-requisites, while the 2013/2014- and the pooled OLS models violated this assumption. Fourthly, the 2007/2008 - to 2010/2011-; and the 2012/2013 to 2014/2015 OLS models for EST323 indicated no significant autocorrelation of residuals, while the 2011/2012 model indicated negative serial correlation. Notwithstanding the non-normality of residuals, the pooled OLS model in Figure 3 did not violate the assumption of independence of residuals.

5. Conclusion

It is concluded that students' scores for the 1st and 2nd semester property development courses varied in consonance with their performance in a variety of co-requisite courses from the 2007/2008- to the 2014/2015 academic sessions. For the 8-year period under review, students' performance in EST311 (Valuation I) was found to be the relatively consistent explanatory variable for scores in the 1st semester property development course (EST313); while EST325 (Estate Accounting), featured as a relatively consistent explanatory variable for performance in the 2nd semester property development course (EST323).

It has been validated from the Multi-temporal analysis of linear regression diagnostics that Building Construction III, Urban planning principles and techniques, Valuation I, and Environmental and Estate Services accounted for nearly 48% variation of students' performance in 1st semester Property Development course, while Building Construction IV, Environmental Impact Analysis, Property Law II, Land Economics II, and Estate Accounting explained nearly 54% variation of students' performance in 2nd semester property development course.

Given that nearly half of the variation in scores earned in Property Development courses is explained by these co-requisites in less than a decade, it is recommended that commitment of tutors/lecturers to the teaching of the core property development courses and their co-requisites is instrumental to a sustained students' pass rate for the 1st and 2nd semesters respectively. It is further recommended that the Estate Management student who is determined to earn good grades in Property Development should accord a reasonable measure of effort towards studying and passing these identified co-requisites, taking into cognisance the variation in model coefficients (weights) that have been allotted to these courses over the 8-year period.

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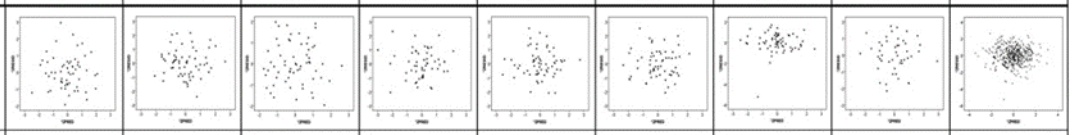
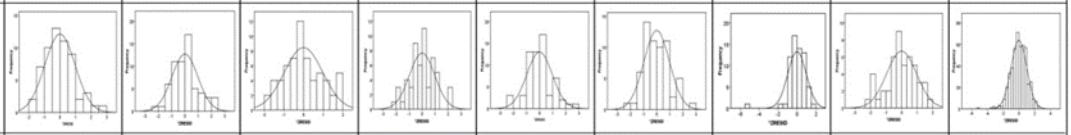
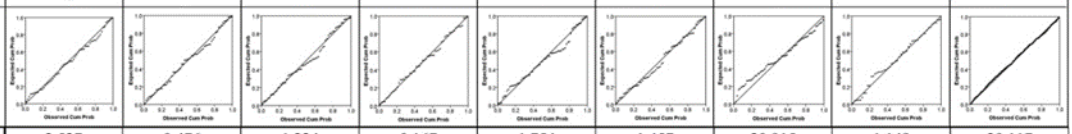
Diagnostic test		Results of 2nd semester EST323 model diagnostic tests								
		2007/2008	2008/2009	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	Pooled OLS 2
VIF of Predictors	Constant	-	-	-	-	-	-	-	-	-
	BLD 302		1.424	1.724		1.577	1.718		1.325	1.387
	URP 406		1.496	1.514		1.776		1.419		1.447
	EST 321									
	EST 322	1.133	1.471	1.608	1.304				1.147	1.411
	EST 324					2.130		1.897	1.281	1.520
	EST 325	1.315			1.255	2.241	1.958	1.601	1.302	1.379
	EST 327	1.294			1.392		1.827			
Average (VIF)		1.247	1.464	1.615	1.317	1.931	1.834	1.639	1.264	1.429
*ZRESID vs *ZPRED										
Normal Plot of *ZRESID										
P - P Plot of standardized regression outcomes										
JB Test	Stat	3.537	0.476	1.224	0.167	1.754	1.457	30.915	1.148	30.117
	p-value	0.171	0.788	0.542	0.920	0.416	0.483	0.000	0.563	0.000
d_w	Stat	1.710	1.574	1.663	1.864	2.351	2.049	1.844	1.456	1.652
	~ *p*-value	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p > 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$
Remarks		Normality of residual Insignificant autocorrelation	Normality of residual Insignificant autocorrelation	Normality of residual Insignificant autocorrelation	Normality of residual Insignificant autocorrelation	Normality of residual Significantly negative autocorrelation	Normality of residual Insignificant autocorrelation	Non-normality of residual Insignificant autocorrelation	Normality of residual Insignificant autocorrelation	Non-normality of residual Insignificant autocorrelation

Figure 3: Multi-temporal diagnostic tests for regression model of EST323 and its co-requisite

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