

Correlation between Formative and Summative Assessment Results in Engineering Studies

Stephen O. Ekolu

*Department of Civil Engineering Science, University of Johannesburg,
Auckland Park 2006, South Africa*

E-mail: sekolu@uj.ac.za, sekolu@gmail.com

Abstract - This paper attempts to study the relationship between results of formative and summative assessments. Generally, there is limited research work available in this subject, most especially relating to engineering education. The study is conducted using data of modules lectured to undergraduate civil engineering students over a period of 10 years. It consists of data sets for 409 students under nine (9) assessment events of various modules.

It is shown that a strong direct relationship exists between semester results and final marks achieved by students. The study found that students that underperform during formative assessments tend to do better in their exams to improve their final marks. The converse is true of students that obtain high semester marks. These findings have the potential to be developed into prediction models that could enable use of formative assessment results for summative purposes. However, further research is needed to expand these findings towards modeling.

Keywords – Prediction model, formative, summative assessment, semester mark, examination mark, final mark, weighting

I. INTRODUCTION

Assessment of educational activities in higher education institutions (HEIs) is an extremely essential part of learning which has the interest of all stakeholders. The stakeholders to learning can be divided into two categories: (a) those internally involved in the learning process including students, lecturers and instructors, administrators of HEIs, (b) those external to the learning process but have vested interest in its outcome i.e parents, industry. To students, the results of assessments are the basis for judgment of their learning progression and is therefore used to determine promotion to the next level of study. In the long-term, assessment results are recorded in academic transcripts and become an indelible information of individuals history which usually have influence throughout his/her career. Parents have a direct and an enormous interest in the performance of students, for they are an investment of the family. All prior learning of students from primary education to tertiary level is attained through the guidance and sacrificial support of parents, it be financial, emotional, psychological support etc. Infact, it is the parents and families that deliberately

pursue the education of learners as a matter of responsibility to well-being of the young, naïve learner. Completion of a study program by a student, culminating into his/her graduation, is often a milestone in the students life, which is marked by celebration of the occasion, of which parents are usually the most jubilant along with the graduand.

The quality of learning offered to the student depends largely on the HEI, which is the paradigm of instruction and learning environment for which lecturers and the institutional administration are crucial players. Mastery of the study subject is drawn from the quality of instruction, for which the calibre of academic staff is indispensable. It is the instructors that construct the curriculum of the study program, decide on the appropriate level of course materials, provide packages of pedagogical tools employed in the learning process, interact with students in and outside of class, may be role models to students as they strive to master the subject matter. Instructors also assess the progression of students during the course of study and adjust their instruction towards improvement of learning, give final assessment of students mastery of knowledge, evaluate and recommend on the student's ability or inability to progress. However, regardless of the calibre of instructors and academics of a HEI, the learning process can be seriously jeopardized in the absence of appropriate resources including academic materials and library, well-maintained lecture halls and classrooms, instruction technologies including projectors, videos, electronic platforms for upload of e-book and course materials. The provision of these critical resources are ensured by administration of the institution. The administration along with academics of a HEI are largely responsible for the quality of learning attainable, quality of graduands and brand of the institution, which in turn has influence on employability of its graduands. The industry which employs graduates has interest in the quality of future employees. Consequently, HEIs often liase with industry to include the perspective of industry into the learning process. Some ways in which this is achieved include incorporation of industry led Advisory Boards within the departments of HEIs, use of industry experts as external examination moderators in summative assessments etc, amongst others.

Typically, during the course of study in any given semester or academic year, there is continuous assessment of modules through assignments, project and practicals, tests. This formative assessment is allocated an appropriate mark prior to

final exam or summative assessment. The purpose of this paper was to examine the relationship between the performance of students during formative assessment and their results during summative assessment, with a view of potentially predicting overall academic performance from formative assessment results.

II. LEARNING OUTCOMES IN ENGINEERING STUDIES

A. Learning outcomes

In most HEIs that offer engineering undergraduate study programs, the success or failure of students in their study programs is judged through the employ of formative and summative assessments conducted at the Departments where the study program is offered. Learning outcomes in engineering studies are pre-defined according to program accreditation requirements, usually set by the relevant governing professional body. In South Africa, for example, the Engineering Council of South Africa (ECSA) [1] which is a signatory to an International Accord recognizing engineering programs in 17 different countries, places a demand on HEIs offering accredited engineering study programs to meet specific learning outcomes. The HEIs are therefore required to measure these learning outcomes based on evidence which demonstrates their attainment at exit level. In engineering studies, the knowledge areas covered in a four-year curriculum would include basic sciences, mathematical sciences, engineering sciences, engineering design and synthesis which form the core knowledge and skills, while generic or transferable knowledge consists of computing, information technology and other complementary studies selected at the discretion of the Department.

At exit levels, the competencies attained by students have to be demonstrated by satisfying several outcomes some of which include problem solving, applied scientific knowledge, engineering design, ability to conduct engineering procedures and investigations as core competencies, while generic competencies include professionalism, technical communication, lifelong learning ability, teamwork abilities, and awareness of the impact of engineering in society [1]. Evidently, effective assessment of these learning outcomes require conduct of both formative and summative assessments at different levels of the study program. For example, a student's ability to conduct engineering procedures and methods, would be assessed through coursework experiments and practicals, while technical communication and/or teamwork would be assessment through laboratory and design projects etc. These forms of assessments fall under the formative category. It should also be considered that the type of assessment influences the manner by which students direct their effort and level of academic performance. Assessments which count highly to the final grade marks are taken more seriously and with greater commitment than those with low or no weighting to final grades [2]-[5]. In most engineering studies, while formative assessments may consist of several components such as assignments, laboratory projects and class tests; summative assessments are usually a single final examination event. It is

common practice in engineering studies that the results from formative and summative assessments contribute equally, to the final mark awarded. This approach compels students to direct their study efforts rationally to both the formative and summative assessments with clear understanding of implications of the results from each assessment type. Instructors also face the challenge of developing effective assessments that truly measure the learning outcomes. In the literature [6]-[7], attempts have been made to define various kinds of criteria that would be used to determine effectiveness of assessments including use of conceptual models.

B. Formative and summative assessments

In the modern educational system, there has been growing interest in understanding the relationship between formative and summative assessments including the possibility of using formative assessments for summative evaluations [8]-[12]. Jain et al [13] reported an existence of a statistically significant relationship between formative and summative assessment marks. Although Carrillo-de-la-Pena [14] did not report any mathematical relations between formative and summative assessments, they found that performance of students in formative assessments was an indicator of better performance in summative assessments. They attributed this relation to the feedback received from formative assessment which in turn causes students to get more effectively engaged in their preparation for summative assessments. Other researchers [15] have reported similar findings.

III. METHODOLOGY

This investigation, which is conducted to study the relationship between summative and formative performance of undergraduate engineering students, is based on data of nine (9) examination events for modules lectured by a single instructor over a 10-year period. The modules consist of structural engineering, construction materials, and civil engineering theory, taught to civil engineering and construction management students in their third and fourth years of study. As seen in Table 1, the class sizes were of small to medium size, ranging from 18 to 86 students, giving a total of 409 data sets. The table also gives results of the semester mark and the final mark awarded after considering final examinations results. The final mark for the C47-module consisted of 30% weighting for semester mark and 70% weighting for examination mark. In all the other modules, weightings for the semester and examination results were 50% each. It is seen that the average semester mark and final mark are quite close, being 57% and 61% respectively. Also, their standard deviations are similar, giving respective average values of 10 and 11 for the semester and final mark results.

Further statistical characteristics of the academic performance of students are given in Fig. 1 for some of the modules. The results in the figure apply to final marks for the modules. Evidently, all the final results exhibit normal distribution characteristics, which is typical of a heterogeneous class of student. All other modules give similar characteristics

as in Fig.1, regardless of class size and academic performance of the class.

TABLE 1
ASSESSMENT RESULTS FOR ENGINEERING MODULES

Module name	Class size	Semester results		Final results	
		Mark	Std dev	Mark	Std dev
S14	69	61.4	9.1	58.0	8.0
C31-11	86	60.9	7.7	60.0	8.7
C31-09	60	59.6	7.8	60.0	11.0
C31-07	42	62.3	9.6	52.1	12.3
C40-11	48	58.1	9.6	67.8	12.2
C40-08	40	55.7	11.8	58.1	14.3
C47-11	24	54.6	9.5	63.4	9.4
C47-08	22	39.5	10.7	42.7	10.3
C47-06	18	60.2	8.4	52.6	11.9

IV. COMPARISON OF FORMATIVE AND SUMMATIVE ASSESSMENT RESULTS

In this investigation, it is intended to determine if there exists any definitive relationship between formative assessment results of students and their performance in summative assessment. The final marks are calculated from the weighting of semester marks and final exam marks. For most modules used in this investigation, a weighting of 50% was used for each component. The relationship between the semester (SEM) mark and the final marks have been plotted for all nine (9) data sets (Table 1), as shown in Figs.2a and 2b. It is interesting to note that upon plotting of semester mark against the final mark achieved by students, a strong and significant relationship between the two sets exists. Generally, students that perform well in formative assessments also do so in final assessments.

Regressions have been applied to the plots in a bid to establish empirical relationships. Both the linear regressions and power functions have been plotted for each data set. It can be seen in Figs. 2a and 2b, that the R-squared values are quite significant, ranging from about $R^2 = 0.5$ to 0.8 . However, in all cases, it is clear that the trendline does not follow the line of equality, regardless of its position above, below or upon the equality line. It is evident that students that obtained lower SEM marks tend to achieve final marks that are higher than their SEM marks. This finding indicates that once students receive feedback of their SEM results, the under-performing students place more effort into doing well in their exams. Hence their final marks tend to be somehow better than their performance in formative assessment. The observation confirms the useful role of formative assessment which is to inform the preparation of students in their learning towards mastery of the study subject [14]. In the converse, students that perform well during formative assessment tend to obtain lower final mark relative to

the SEM mark. This trend may be attributed to lack of desperation on the part of students that perform well in formative assessments, lending relatively moderate effort in final examinations as compared to their counterparts with low semester marks.

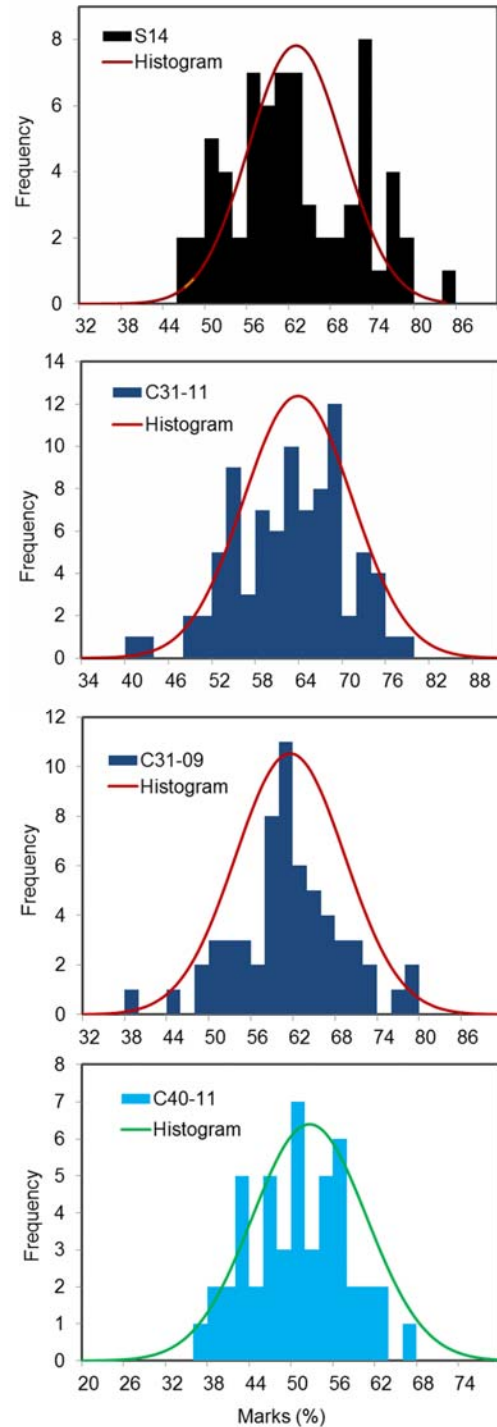


Fig. 1 Histogram of final mark results

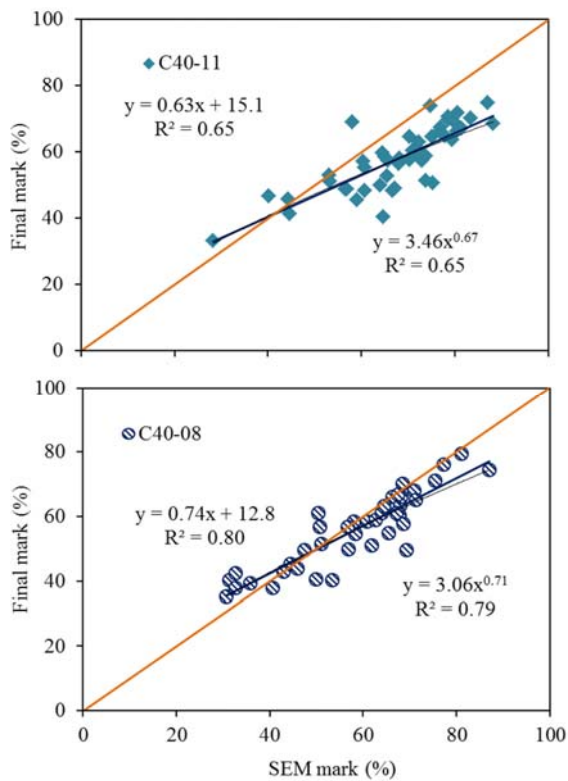


Fig. 2a Final marks versus semester marks for C40-11 and C40-08

V. CONCLUSION

A study was conducted to compare the relationship in academic performance of students in formative and summative assessments. Formative assessment marks are accumulated during the learning period through assignments, projects and class tests. Summative assessment consists of final examinations while final marks are awarded upon weighting of both semester marks and final examination marks. It was found that a strong relationship exists between semester marks and final marks attained by students. Accordingly, it may be possible to estimate the corresponding final marks using semester results.

Data shows that when the semester mark is low, the final marks achieved by students are higher as students improve their performance in final exams. But for students that obtained high semester marks, the final mark is generally lower than their semester mark. These results underscore the useful role played by formative assessments to improve the preparation of students towards subject mastery.

Further research is needed to determine models that may be applied towards potential use of formative assessments for summative purposes.

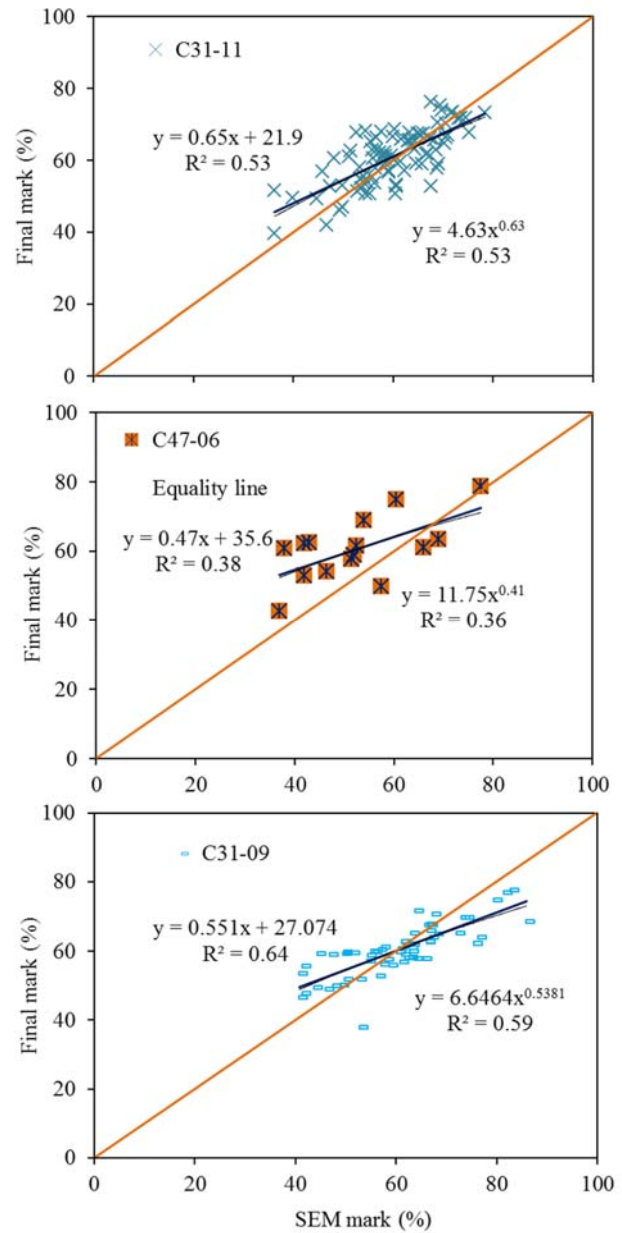


Fig. 2b Final marks versus semester marks for C31-11, C47-06 and C31-09

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