A Simple Tool For Quality Assessment In Education

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Abstract

A quality assessment tool is presented to detect the presence of out-of-control conditions in a school course system. The tool detects whether or not a set of courses offered by a certain discipline constitutes a stable (or in-control) system of courses. A system of courses is said to be stable if the variation in students' performance from course to course is only due to common causes. Students' performance in a course may be measured by their term grades in that course or any other method of evaluation. The proposed quality tool has the advantage of being applicable to numerical grades as well as to ordinal letter grades such as A, B, C, etc. A further advantage is that the proposed tool can be implemented graphically as a quality control chart. A pilot case study of the proposed tool was initiated in Fall 1995 to monitor a system of six of basic 200-level courses in the Department of Business Administration at Alabama State University. The results of this pilot study show that the system was out-of-control for the period Fall 1995 to Fall 1999 and then became in-control in Fall 2001.

INTRODUCTION

Recently there have been serious efforts to incorporate quality management concepts and tools into education to improve the performance of students. Students' performance is usually measured by the grades they attain in their courses. Naturally, those courses in which students perform poorly need special attention from the school administration and the educators. Therefore it is always worthwhile to develop assessment and feedback techniques to monitor students' performance in the various courses and to identify the courses in which students perform poorly. It is desirable that such techniques be simple enough to be routinely applied and easily interpreted by most educators. Examples of quality management efforts in education may be found in Higgins (1991), Hubbard (1993), Ritter (1992, 1993), Jenkins (1997) and Carson (2000).

In this article, we present a quality tool that we found quite effective in identifying the courses in which students perform significantly different (better or worst) from their general average performance in other courses. Courses in which students perform significantly better are less worrisome to educators except for the fact that students could be getting high grades easily. Courses in which students perform poorly are of serious concern and need to be identified by educators.

Suppose that we wish to examine the variation in students' performance in a given system (set) of courses offered by a certain school. According to the Total Quality Management (TQM) theory and to Deming's (1986) teachings, we must distinguish between the "common causes" and the "special causes" of variation affecting the performance of students in the courses of the system. To borrow from statistical process control (SPC) terminologies, we will adopt the following two definitions:

Stable System

The system of courses under study is said to be *stable* or "in-control" if the variation in students' performance in the courses of the system is due to only *common causes*. Common causes are inherent in the system and they affect every course. In such a stable system, students face similar instructional environments (instructors, instruction aids, grading policy, difficulty of content matter.)

Unstable System

The system of courses is said to be *unstable* or *out-of-control* if the variation in students' performance in the courses is due not only to common causes but also to additional *special causes*. In such unstable system, there are special causes associated with the instructional environments of some specific courses that may be termed "out-of-control" courses. The special causes tend to enhance or depress students' performance in the out-of-control courses.

It is well known that control charts are the most commonly used tools to detect the existence of special causes and to monitor the stability of a system. The implementation of most traditional control charts require quantitative data on the interval scale of measurement so that the normal, binomial, or Poissson distributional properties could be used to calculate the control limits of the chart. This requirement causes some difficulty in constructing control charts to monitor students' performance since students' performance is usually reported by categorical measurements on the ordinal scale such as A, B, C, etc. The quality tool that we propose in this article is readily applicable to categorical data on the ordinal scale as well as to numerical data on the interval scale of measurement.

It will no doubt be enlightening to an educator or to a school administrator to identify the out-of-control courses, if any, in the school course system. It should be mentioned, however, that a statistical control chart detects the existence of a special cause of variation that lies outside the system; but it does not identify the cause (Deming (1986, pp 312)). Additional investigations by the school administration must be carried out to pin point the major special causes affecting the system. Pareto charts and cause-and-effect diagrams are useful in this respect. Some special causes behind the out of control courses that come to mind are: Severe difficulties of course content matter, poor instructions and facilities, poor students' background, unfair departmental or instructor's grading policies, etc. Once identified, many special causes can be eliminated by departmental and/or instructors' efforts leading to improved students' performance and to a more stable course system. It is admitted here that some courses may legitimately widely vary in the difficulty of the content matter and little can be done to eliminate this special cause. We suggest that the educator compares students' performance in a target presumably homogeneous (e.g., same academic level) set of courses. In the pilot case study that will follow, the authors compare six core 200-level courses required from all business students in the college.

The quality tool that we propose in this article is based on the idea of replacing the grades of students by numerical ranks and then applying the method of *analysis of means* using ranks as developed in Bakir (1994)**.** Using these ranks, a course performance index will be calculated for each course in the system under study. The tool will be developed as a quality control chart that gives an out-of-control signal whenever any course performance index falls outside the control limits. The proposed tool has the following merits of being

1) applicable to quantitative data (grades of students) on the interval scale as well as to qualitative data on ordinal scale such as A, B, C, etc.
2) a nonparametric statistical method where it is not required to assume that the data (grades of students) follow a certain probability distribution. The control limits can be computed exactly without the need to estimate the grand mean, the standard deviation, or the need for assuming a specific underlying probability distribution (such as the normal or otherwise) for the grades.
3) capable of graphical implementation on a chart similar in spirit to a quality control chart. The resulting chart not only shows the existence of a significant difference among courses but it also identifies the out-of-control courses, if any.

THE PROPOSED QUALITY ASSESSMENT TOOL

The proposed quality assessment tool will be presented as a control chart where one plots certain performance indices representing the various courses in the system. The control limits of the chart are determined statistically. The chart gives an out of control signal if at least one course performance index falls outside the control limits. In control chart applications, it is usually desirable to restrict the false alarm rate, which is the probability that the control chart signals when the system is in fact in-control. The determination of the exact control limits of the proposed chart does not depend on the underlying probability distribution (normal or otherwise) of the data (grades of the students in the various courses of the system). Further, it is not required to estimate the mean or the standard deviation of the data, in order to set the control limits of the chart.

Suppose that it is of interest to examine the stability of a system (or a subset) of *k* courses offered by a certain school. The proposed quality tool is best explained in the following steps:

Step 1: Obtain a random sample of a convenient size, *n*, from the population of all students who already took the *k* courses in a certain school term or year. Record the grades of the sampled students in each of the *k* courses. The grades may be on the interval scale of measurements or on the ordinal scale such as "A, B, C, . . .". In statistical terminology, the data thus obtained constitute a randomized complete block design with *n* blocks (the students) and *k* treatments (the courses).

Step 2: For each student separately, replace his/her grades in the k courses (from least to largest) by numerical ranks from 1 to *k*. In case of ties, compute the average of the ranks of the tied courses and assign it to each of the tied courses. Denote by r_{ij} the rank of the grade of the ith student in the jth course.

Step 3: Compute the rank total of each course $R_{.j} = \sum_{i=1}^{n} r_{ij}$, for j= 1,2, . . . , *k*. When the system is in-control, it can be verified (Conover 1971, pp 269) that the rank totals have a mean □ and a variance □^{2} given by

□ = n(k+1)/2 and □ ^{2} = n(k+1)(k-1) /12. (2.1)

Step 4: Compute the course "performance index," $D_{.j}$, as

$D_{.j} = R_{.j}$ - □, for j= 1, 2, ... , k. (2.2)

Step 5: Construct a quality control chart for the system of *k* courses as follows:

Let the horizontal axis represent the course label or number (j=1, 2, ..., *k*) and let the vertical axis represent the course performance index $D_{.j}$. For j= 1, 2, ..., *k*, demarcate the points (j, $D_{.j}$) on the control chart. Draw two horizontal lines to represent the upper control limit (*UCL*) and the lower control limit (*LCL*) as given by

$UCL=d$, and $LCL= - d$ (2.3)

The exact value of *d*, which depends on both k and n, can be read from Table A.1 in Bakir (1994), which tabulates the exact probabilities of false alarm rates:

$$P(|D_{.j}| > d \;\; for\ at\ least\ one\ j\ when\ the\ system\ is\ in-control) \,. \qquad (2.4)$$

In practice, one chooses *d* to ensure that the false alarm rate be equal to a certain desired value, say □. For large values of the sample size, *n*, the value of *d* may be replaced by □□(□;k), where □(□;k)is read from Table IV of Bakir (1989), which abridges Nelson's (1983) computations of the large sample approximations for the probability in (2.4).

Step 6: Conclusion: Make your decisions as follows:

1. The system of courses is stable or is in-control, if all the points (j, $D_{.j}$) fall within the control limits *UCL* and *LCL*.

2. The system of courses is unstable or is out-of-control, if at least one point (j, $D_{.j}$) falls outside the control lomits. The courses corresponding to the points that fall outside the band are "out-of-control." These are the courses in

which students, due to special causes, perform differently from their average performance in the entire system of the k courses.

Step 7: Quality improvement:

The courses whose points fall below the *LCL* are the ones in which students' performance is significantly worst than their performance in the system as a whole. Conduct further studies (e.g., Pareto and cause-and-effect analyses) to identify the nature of the special causes that are responsible for the poor performance of students. See, e.g., Ritter (1993.) Similarly, courses whose points fall on the good side may be investigated to see what particular positive special causes are helping the students to perform well.

A PILOT CASE STUDY

A pilot case study of the proposed tool was initiated in Fall 1995 to monitor a system of six basic 200-level courses in the Department of Business Administration at Alabama State University.

These courses were: ACT 211 Fundamentals of Financial Accounting (changed to ACT 214 thereafter), CIS 206 Micro Computers, ECO 201 Business Mathematics, ECO 202 Bus Stat I, ECO 252 Principles of Economics II, and MGT 204 (Business Communications)

At the end of each of Fall 1995, Fall 1997, Fall 1999, and Fall 2001, a random sample of *n =18* students was selected from all students in the Department of Business Administration who already took those courses. For illustrative purposes, Table 1 in the Appendix shows the grades (reported as A, B, . . .) of the sampled students and the necessary computations (rank assignments, etc.) for Fall 1995. Using equation (2.1), computations show that the mean and variance of the rank totals are:

□= 18(7)/2 =63, and $\square^2$ =18(7)(5)/ 12 = 52.5

Since the sample size *n =18* is large enough, we will calculate the large sample approximation of the control limits. Reading Table IV in Bakir (1989) with *k= 6* and □=0.05, we obtain □ (□; k) =2.62. Therefore,

UCL = □□(□;k)= (7.25)(2.62) = 19.0, and *LCL* = □19.0

Now proceed according to Step 5 of section 2 and construct the control chart. Figure 1 represents the resulting control chart for the system under study as of the end of Fall 1995.

Examining Figure 1 in the Appendix, it is seen that the system of six courses is "out-of- control" because one point corresponding to ECO 202 falls below the *LCL*. Therefore, students' performance in ECO 202 is significantly lower than their average performance in the system. Attention should be directed towards ECO 202 in order to identify and remove the special causes that tend to depress students performance in this out-of control course. After taking some rectifying actions to improve students' performance in ECO 202, an educator can recheck the stability of the system of courses in subsequent school terms by repeating the steps outlined above. Eventually, the educator will have a control chart that extends over several school terms.

We repeated the control charting at the end of Fall 1997, 1999, and the end of Fall 2001. Figure 2 in the Appendix represents a quality control chart for the same system of courses that extends from Fall 1995 to Fall 2001. Studying Figure 2 leads to the following conclusions:

1. The course system under study was out-of-control in Fall 1995, Fall 1997, and in Fall 1999. ECO 202 fell below the *LCL* in 1995 while MGT 204 was above the *UCL* in 1997 and 1999.
2. The course system under study became in-control in Fall 2001 because no course was outside the control limits. The six courses have become quite close to each other. This should be encouraging news to the Department of

Business Administration. The leadership of the Department must have implemented some positive educational policies that brought the system to the in-control state. While a further study is needed to pin point these positive policies, one can speculate on some of them. Recently faculty members have been encouraged and instructed to work together and discuss their teaching/coaching methods. This is manifested through team teaching/coaching, class visitation, etc. Positive and negative experiences were evaluated and shared among all instructors.

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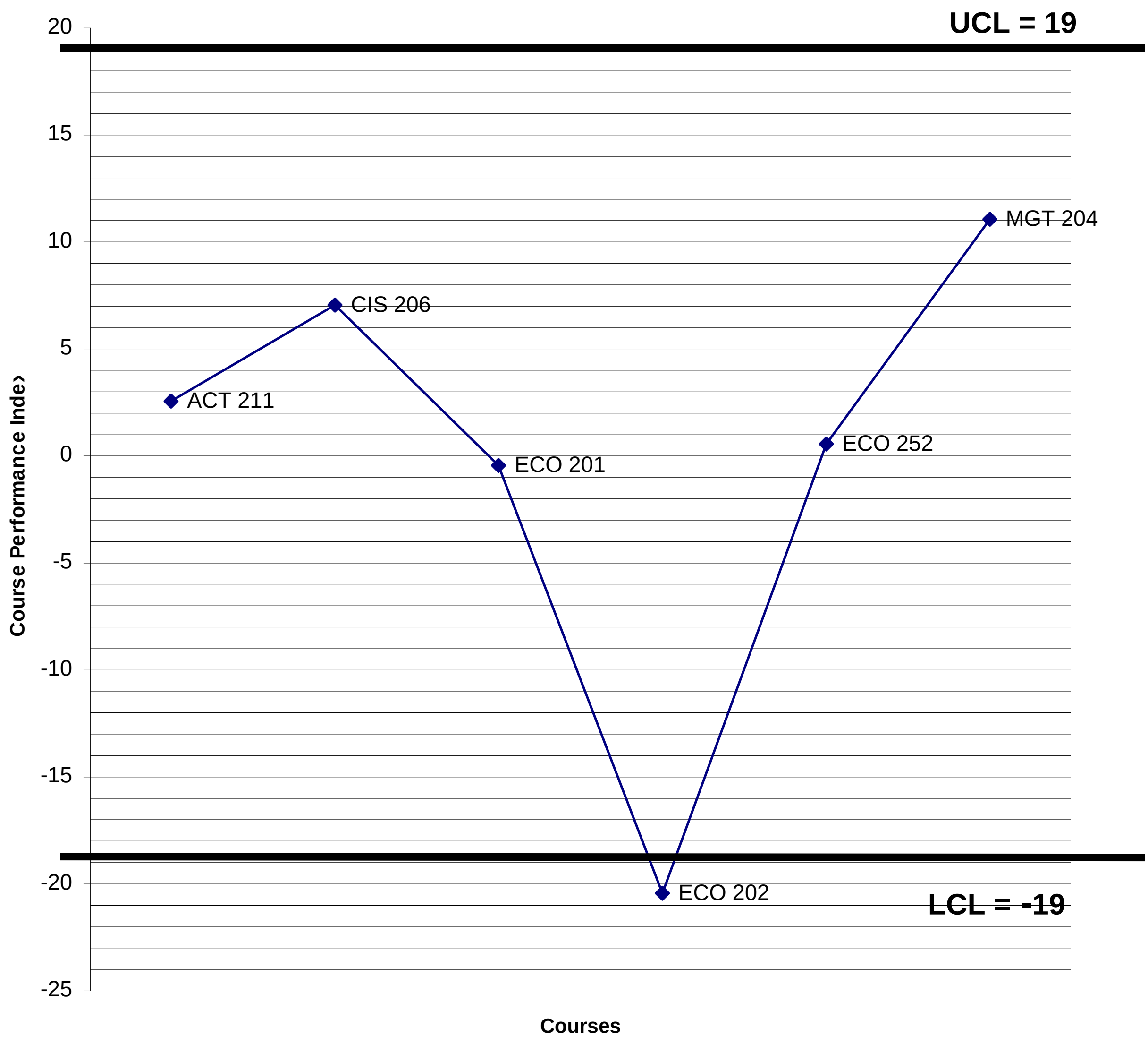
APPENDIX

Table 1: Letter And Rank Grades Of *N = 18* Students In A System Of *K = 6* Courses For Fall 1995.

Student No.	ACT 211	CIS 206	ECO 201	ECO 202	ECO 252	MGT 204
1	B 1.5	A 4.5	A 4.5	A 4.5	B 1.5	A 4.5
2	B 6	C 3.5	C 3.5	D 1	C 3.5	C 3.5
3	B 3.5	B 3.5	B 3.5	A 6	C 1	B 3.5
4	F 1.5	B 6	C 4.5	F 1.5	C 4.5	D 3
5	B 5	C 3	B 5	D 2	F 1	B 5
6	C 2.5	C 2.5	A 5.5	D 1	B 4	A 5.5
7	D 4	F 2	F 2	F 2	C 5	B 6
8	D 1.5	C 4	B 6	D 1.5	C 4	C 4
9	C 3	B 5.5	F 1	B 5.5	C 3	C 3
10	C 3.5	D 1.5	B 5.5	D 1.5	B 5.5	C 3.5
11	A 6	D 1.5	D 1.5	C 4	C 4	C 4
12	C 5	C 5	F 2	F 2	C 5	F 2
13	C 4.5	C 4.5	C 4.5	D 1.5	D 1.5	C 4.5
14	F 2	D 4.5	F 2	F 2	D 4.5	C 6
15	C 3	B 6	C 3	C 3	C 3	C 3
16	C 4	C 4	D 2	F 1	C 4	B 6
17	B 3.5	A 5.5	B 3.5	C 1.5	A 5.5	C 1.5
18	B 5.5	C 3	C 3	D 1	C 3	B 5.5
Total $R_{.j}$	65.50	70.00	62.50	42.50	63.50	74.00
Rank Deviation $D_{.j}$	2.50	7.00	-0.50	-20.50	0.50	11.00

Figure 1: Control Chart for Course System, Fall 1995.



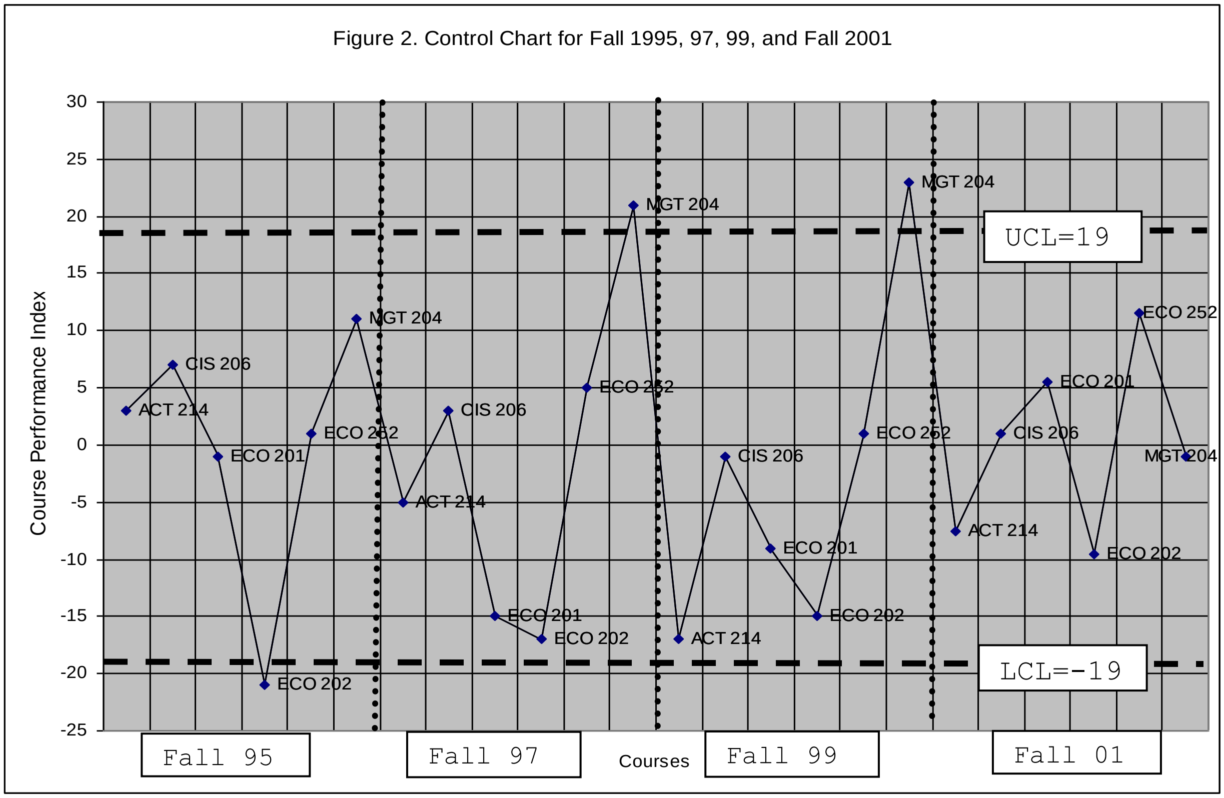


Figure 2. Control Chart for Fall 1995, 97, 99, and Fall 2001
Course Performance Index
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
ACT 214
CIS 206
ECO 201
ECO 202
ECO 252
MGT 204
UCL=19
LCL=-19
Courses
Fall 95
Fall 97
Fall 99
Fall 01

Notes