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QUALITY IMPROVEMENT SCHEMES IN INDIAN ENGINEERING EDUCATION

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In this, a statistical process control model has been developed for monitoring, control and improvement of the teaching process and learning outcomes. The model has considered lectures, and laboratory experiments as the most common constituents of an engineering undergraduate course. Using this approach, universities are able to make the claim for exceptional student performance and/or disprove the claims that their instructional systems are the cause of poor student performance. A case study regarding the issue discussed has illustrated a remarkable reduction of critical students' errors in a mechanical engineering laboratory.

Keywords: Quality Control, Quality Improvement, Classroom Assessment Techniques

1. Introduction

'What does quality in education mean?', 'How can universities assure the general public of the quality of educational services provided?', 'How can universities improve quality?' A quality system is a set of interdependent processes that function harmoniously, using various resources to achieve objectives related to quality and create quality characteristics that will meet customer needs [2]. An established quality system requires certain resources, such as people, material and information, to achieve set goals and objectives. Organization, responsibility, authority and interrelationship between people whose work affects quality of the product must be defined. Documented resources are also needed to describe and control processes within the quality system, and to provide evidence of an effective and efficient quality system to interested parties, such as customers, external organizations or management. Quality system documentation is commonly designed in a four-tier fashion. The top document is the Quality manual, which describes the overall quality system and refers to the necessary quality system procedures. Each documented procedure illustrates one or more processes. In the university environment, procedures may describe purchasing of material for teaching/learning or research activities, appointment of teaching assistants or the teaching process control. The ISO 9001 quality system in a university department, through process control, statistical techniques and internal quality audits can achieve an objective of creating zero-defect students, which would at this point of time certainly surpass the expectations of its customers.

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2. Quality Control and Improvement

Quality control of the common constituents of a university course: lectures and laboratories is addressed, followed by a description of the tools for quality improvement. Students are continuously tested through term tests, assignments, projects, quizzes and exams. It seems, however, that the quality control (QC) techniques used in education today are at the level of manufacturing QC in the twenties. Term-tests and exams resemble the 'go-no-go' gauges [3]. Rather than comparing a student's knowledge and competence with the performance of his/her class peers, it should be compared against an established standard. Quality knowledge and competence must be built into students, and not just inspected at the end of a course or program If there is any inspection and testing to be done, it should be done continuously before and after every lecture, laboratory and tutorial, much like in the Toyota production system where a product is continuously inspected after each operation and before every consecutive operation. Techniques such as Statistical Process Control (SPC), Analysis of Process Capability, Acceptance Sampling, or the 'Seven Quality Control Tools', together with established classroom assessment techniques, can be used to build in quality on a continuous basis [4].

3. Quality control in lectures

Combining Classroom Assessment Techniques (CATs) [1] with control charts provides the possibility to control learning outcomes and the teaching process. In this a modified

Background Knowledge Probe (BKP) is used to measure the learned material, together with plotting a control chart of results as a statistic. A BKP requires students to write short answers and/or circle the correct responses to multiple choice questions, and provides feedback on students' poor learning (Angelo and Cross, 1993) [5]. A modified BKP for a lecture would ask the students about their prior knowledge on the matter to be taught at the beginning of a lecture, but would also ask the same questions at the end of a lecture. For example, the one question is answered correctly by 19 out of 48 students before the lecture and 47 after the lecture, with 28 students who learned the answer during the lecture. On average for the lecture, 90.4% were correct after, with 52.5% whose learning can be attributed solely to the lecture. If a professor wishes to observe the performance on each individual question, an attribute 'p' chart can be used with the p_c and/or p_L statistics directly plotted for each question. This chart can also be used in the examination of performance from lecture to lecture.

3.1. Implementation Procedure for a P-chart

Step 1: For each question in BKP, record the number of students who were wrong or did not know the answer before and were correct after (L_i), as well as the total number of students (n_i).

Step 2: Treat each question as a subgroup (sample), and the number of students who answered each question as the size of the subgroup (n_i). For instance, if 25 students answered the first question and 24 answered the second one, then $n_1 = 25$ and $n_2 = 24$. Evidently, subgroup size may change from question to question and will most certainly change from lecture to lecture, depending on the number of students attending. The number of questions given represents the number of subgroups (g).

Step 3: If we assume that there is an equal probability of each student being wrong before and correct after, that the students are independent of each other, and a sample of n students is taken, then the statistic p_L should be binomially distributed. Thus, a p-chart with the following central line: CL = p where $p = (\Sigma L_i)/(\Sigma n_i)$, i = 1,2, ...,g, and control limits: $p \pm 3(p(l-p)/n_i)^{0.5}$ is plotted. These limits can be established after about 25 subgroups, i.e. 25 questions. For example, if each BKP contains 5 questions, a p-chart can be plotted after five lectures.

Step 4: Plot the proportions $p_{Li} = Li / n_i$ on the chart.

Step 5: Identify assignable causes of variation. Empirical rules for indicating out-of control conditions can be found in [11, 12]. Also, the next section on the Xbar-chart will provide some interpretations of out-of-control conditions that cm be applied here, as well.

Step 6: Eliminate points for which assignable causes of variation have been found. Recompute the control limits and continue monitoring the teaching/learning process.

3.2. Case Study

The above-mentioned approach has been used to monitor and control classroom Lecture in mechanical engineering course. A modified BKP with five questions (n=5) has been applied in nine (g=9) lectures. Classroom attendance has been in the 35-50 range. A p-chart drafted for the pc statistic (Figure 1) shows three points, corresponding to questions #10, 32 and 37 well below the lower control limits, indicating out-of-control conditions. The analysis illustrates that all three questions were numerical in nature, requiring the students to apply the knowledge of several theoretical concepts to solve the problem.

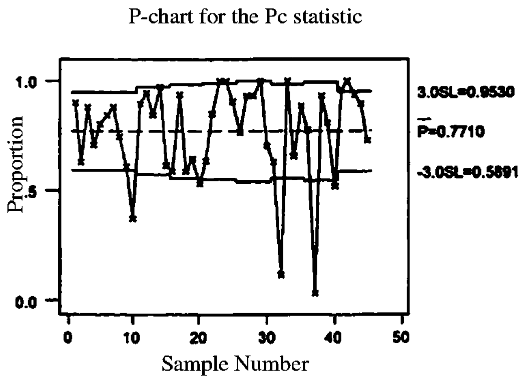

Fig 1: p-Chart for pc in Lectures

Low output may indicate that students did not have the time or motivation to solve these problems (it did not count for marks), but also that more emphasis should be given to practical applications of theory.

4. QUALITY CONTROL IN LABORATORIES

4.1. Approach to Quality Control

Laboratory experiments in engineering education differ from classroom lectures in that a class is usually divided into smaller groups of students. Also, contrary to lectures, which present new material with each new lecture, laboratory experiments are repetitive in the sense that each group of students is required to perform essentially the same experiment. Nevertheless, the approach to quality control in laboratories is similar to the one for classroom lectures [7].

Since the measured parameters are counts, and the number of students in each laboratory session can vary, a u-chart for defects per session is suggested [8]. First, the average number of defects (say incorrect answers after the session) for each laboratory session $u_j = (\Sigma c_i)/n_j$, is calculated. Here, i = l, 2, . . ., n_j denotes an individual student in the j-th group; c_i is the count of either the incorrect answers for each student or the number of questions with an incorrect answer before and a correct answer after for each student; n_j is the number of students in each session; and j = 1, 2, ..., g is the number of laboratory sessions. After these calculations, the center line is established as $u^* = (\Sigma U_j)/g$, control limits as $u^* + (u^*/n_j)^{1/2}$, and control charts plotted and analyzed. The analysis of out-of-control conditions is similar to the classroom lecture case.

4.2. Case Study

The approach for quality control in a laboratory setting was studied using a second year mechanical engineering (thermodynamics) course [6]. Students were divided into 16 groups of 7 students in average, each group performing a 1.5 hour-long experiment on a different day. The BKP was applied at the beginning and end of each session. Groups of students performing the experiment on a particular day were treated as subgroups (g=16), with a variable subgroup size, due to the fact that some students were not able to participate on a scheduled date. Thus, 'n' varied from 4 to 9. A u-chart was drafted for the statistic (Figure 2). The control chart indicates in control conditions, with a downward trend on the chart for the first seven groups. .

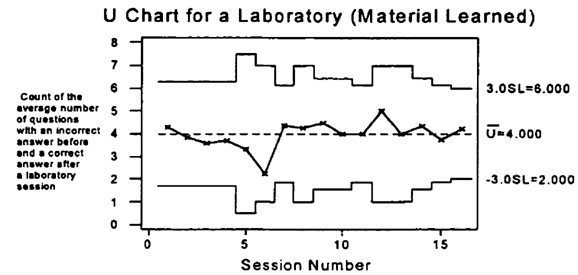

Fig 2: U-Chart for a Laboratory

The students might not have had enough time to read lab notes before the session, causing the statistic to fluctuate at a higher level.

5. CONCLUSION

The model has considered lectures and laboratory experiments as the most common constituents of an engineering undergraduate course. Some of the benefits of this approach include:

- Information on the incoming variation in student 'baselines knowledge is provided;
- Information on how much and how well the students have learned the material is provided;
- 'before' and 'after' knowledge can be compared to roughly estimate the value-added outcome;
- effects such as when a student knew the answer before but not after can be examined;
- students are focused on the most important issues in a lecture.

Using this approach, universities are able to make the claim for exceptional student performance and/or disprove the claims that their instructional systems are the cause of poor student performance.

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