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A Statistical Approach for setting SLO targets over Outcome Based Education-A Case Study

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Abstract: One of the major challenges in engineering education is to train the students in an efficient way to determine the exposable skills in a collaborative manner to solve complex and weakly structured problems. This research work focus towards the development of a predictive data analytical model using statistical inference techniques. Each of the courses instructed to the students will have certain outcomes to be addressed. Experimental evaluation has been done with the non-applicability of active learning strategies and applicability of active learning strategies over the course outcome values attained by the students over the two batches of students. The data has been formalized to normal distribution to discover the statistical relevance. Newly formulated control limits have been established to determine the course outcome target value. With the initialization of heuristic values we came to a conclusion over the target fixing mechanism for the attainment of course outcomes. Hence from these results we can obviously fix the student target measures for any subjects by which we can deploy the mechanism of deliverables over the reality and the nature of the courses to be learnt.

Keywords: Predictive Analysis, Statistics, Education Technology, control limits, course outcomes, target measures.

1. Introduction

This paper introduces the concept how to set or fix targets for learning objectives of different courses of Engineering Education. The attainment of targets of learning outcomes (LOs) depends of three different factors like curriculum, content delivery and assessment. All these factors need equal importance. While fixing targets for these LOs, the challenges and difficulties involved in implementing these factors need to be considered. Also, all targets need to be SMART (Specific, Measurable, Achievable, Realistic, and Timely). Targets cannot be fixed by an individual using his or her own experience, which leads to probabilistic approach. The targets may be fixed statistically, so that it can be easily correlated for future reference.

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2. Related Works:

Nikkie.et.al,(2016) dealt on the setting of student learning objectives(SLO) and various issues related with it. Further the Measures of Academic progress (MAP) has been fixed by them with some parameters and evaluated.

This work (Gloria.et.al, 2013) proposed the measurement of interest to use mobile phones by the social science teachers across various secondary schools. The response was positive from most of the schools and the teachers of social science expressed their opinion on using mobile phones for learning social science. The factors like age and educational setup were found to be the reason for their opinion and further this paper discussed the advantages of m-learning in detail.

With the growth of smart phones and IoT devices, mobile big data has grown enormously. To perform deep learning technique, a spark-based framework (Mohammad Abu.et.al, 2016) have been introduced which has several hidden layers and number of parameters to be examined and worked on. This framework has been validated for large-scale activity.

A task interaction framework (Marco Arrigo et.al 2015) was proposed to evaluate the mobile learning techniques. This was mainly targeted towards examination of results off the classroom through the application of learning analytics which involved the usage of the framework for result interpretation. Results are analysed based on various factors for mobile learning techniques. In this paper, we have suggested SMART target values for LOs of first year courses of engineering education based on the past academic results.

3. Methodology

Achieving targets is strongly correlated with motivation and academic performance. The existing techniques do not incorporate the active learning techniques for effective teaching learning process. The inclusion of the ALS in the proposed target fixing scheme helps to improve the quality and standard of the learning abilities of the students with improved techniques. So the competency based Education system (CBE) is replaced with the outcome based system in which the Active learning strategies are implemented and the target fixing is done based on the new technique with parameters fixed based on the ALS.

Along with the goal setting, we have devised suitable action plan for their target achievement. We have incorporated different style of content delivery methods in the form of Active Learning Strategies (ALS) to improve students' learning. We have also included different

assessment methods for evaluating their academic knowledge and soft skills like individual/team building skills, communication and presentation skills and so on. This helps each student to reach his or her objectives in an efficient way. The attainment level of students is evaluated through 3sigma technique.

In this section we describe qualitative and quantitative methods that we have used for setting up targets for LOs.

3.1. Qualitative methods

Qualitative methods are mostly used for target setting. They are used to set baselines based on experience and past performance. In the absence of sound data for estimating, ***expert opinions*** is the right choice for target setting. Expert opinions can be determined in focus groups or through questionnaires. A disadvantage of focus groups might be the tendency of a dominant group member to exert influence the opinion of the other group members.

In the *Delphi method*, experts give their opinions or estimates in more than one round (usually two or three). After each round, a facilitator provides summary of everybody's choice. In the next round, the participants can revise their earlier answers, if needed. The process is stopped when the consensus is reached among all. Delphi is based on the principle that forecasts from a structured group of individuals are more accurate than those from unstructured groups. Targets fixed by this method may be less accurate than the quantitative method.

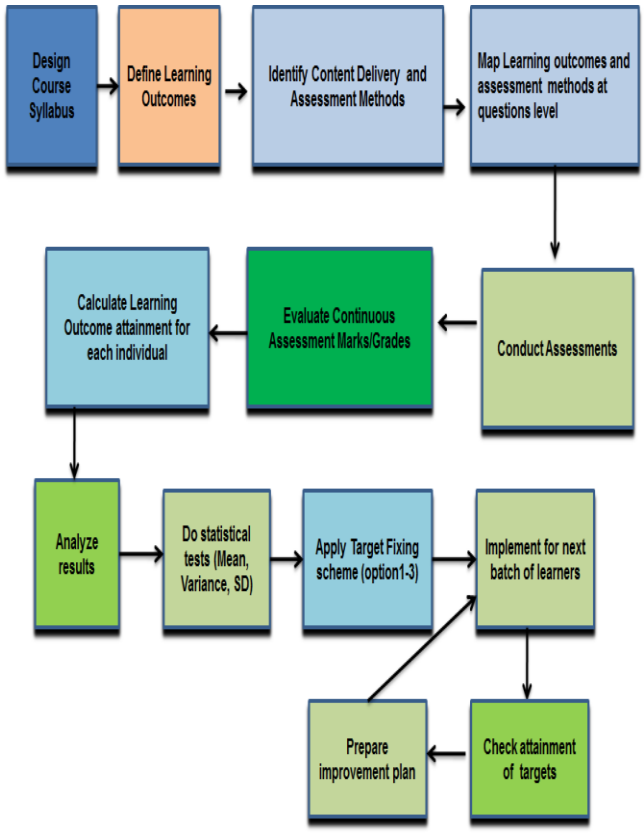

Figure 1 Framework for target setting

3.2 Quantitative methods

Statistical approach for setting up the targets is more accurate compared to qualitative methods, when historical data is available.

3.2.1 Basic target method

Class average (or mean) and standard deviation are calculated on the students' performance on each learning objective. Depending on the complexity (or attainment) level, the course faculty can decide what could be that target from the mean value. It can be 1 sigma range, or 2 sigma range.

3.2.2 Half the distance target method

This method finds the maximum and minimum value for each learning objective. The target value can be selected by adding these two values and then half it.

3.2.3 Tiered target method

Basic target method can be slightly modified into 'tiered targets' methods. Some LOs may be easy to attain and some may not be easy to attain. For tier 1 (easy) LOs, the targets can be fixed at 2 sigma level. Because most of the students perform well and reach this target. For tier 2 LOs, the targets can be fixed at 1.5 sigma level and so on. For tier 3 LO, the class average may be very low, which cannot be accepted as the target value. For these LOs, apart from regular academic performance test (which measures knowledge), different assessment methods for measuring their skills and behavior (attitude) need to be planned and measured. This helps in achieving tier 3 LOs easily with greater effectiveness.

3.2 4-Sigma computation

3sigma computation is a statistical technique, which refers to the calculation of data in accordance to three standard deviation from the mean value. The limits are used to set up the upper control value and lower control value in statistical control charts. The process control chart is a form of graph which is used to study the variations in the data level (process) over time. It has an upper control limit value, lower control limit value and a central average value line. They are used to determine the state of art of the process in the form of statistical control value. The central line in the control chart is the value of the mean of statistic. The upper and the lower control limit value determine the threshold value in which the process output is considered statistically.

If all the points in the process control chart falls between the control limits and any of the observations fall outside the limits with some patterns, it signifies the introduction of a new causes of variation. This provides the control limits value for decision making process at regular intervals. The main target behind the process control chart is to determine the events with the indication of actual process change. Hence it provides statistical objective measure of change from continuously varying function. If the change of measure is of a good cause then it can be considered for evaluation and if the cause doesn't fit within the scope then it can be eliminated. The following table 1 and table 2 provide the values for fixed targets which have been assigned heuristically.

Table 1 Defined Course Outcome with Control Limit Values

S.No	Outcome Value (Attainment % - heuristically assigned)	Limit Observed	Inference

CO1	85	Above CL	The fixed target is feasible / raised
CO2	80	Below CL	The target value has to be taken into consideration
CO3	80	Above UCL	The target can be raised to a level above 80
CO4	80	Between mean CL and LCL	The fixed target is feasible
CO5	80	Below LCL	The target value has to be taken into consideration
CO6	80	Between mean CL and LCL	The fixed target is feasible

Table 2 Defined Course Outcomes with Control Limit Values

S.No	Outcome Value (Attainment %)	Limit Observed	Inference
CO1	85	Between the UCL and LCL	The target can be raised to a level above 80
CO2	80	Between CL and LCL	The fixed target is feasible
CO3	80	Between CL and LCL	The fixed target is feasible
CO4	80	Above UCL	The target can be raised to a level above 80
CO5	80	Above UCL and some ranges to LCL	The target can be raised to a level above 80
CO6	80	Above CL and between CL and LCL	The target value has to be considered

3.3 Proposed Target fixing scheme

The target fixing scheme has been introduced with accordance to the values observed. In the first method the assumption has been made correspondingly with the following formula:

$$T\arg et\_value = \left(Avg - \sigma, Avg, Avg + \frac{\sigma}{2} \right) \quad (1)$$

The observed measurement has been made for all the course outcome values in order to determine the target values. With this significant measurement the ratio of number of students who have felled in the defined intervals has been found. The following table 3 describes the observed statistical values for course outcomes corresponding to the batch of 2014-15.

Table 3 Observed statistical values for course outcomes over 2014-15 batch

S.No	Standard Deviation	Variance	Sum	Mean	Standard Error of the Mean ($SE_{\bar{x}}$)
CO1	24.30	590.63	7037	59.63	2.2468
CO2	21.39	457.65	6660	56.44	1.9777
CO3	18.67	348.77	8834	74.86	1.7265
CO4	27.16	738.04	5235	44.36	2.5115
CO5	28.58	817.31	5603	47.48	2.6430
CO6	19.76	390.77	10230	86.69	1.8275

In the second method of determining the outcome values the following equation provides the mechanism of assessment for the defined course outcomes.

$$T\arg et\_value = \left(Avg - \frac{\sigma}{2}, Avg, Avg + \sigma \right) \quad (2)$$

The evaluation with this method proceeds by examining a part of the sigma values for one end and with the other end the addition values of sigma proceeds. The second method will provide some obvious measurement over the outcomes that are to be addressed.

Table 4 Observed statistical values for course outcomes over 2015-16 batch

S.No	Standard Deviation	Variance	Sum	Mean	Standard Error of the Mean ($SE_{\bar{x}}$)
CO1	23.64	558.90	8464	71.72	2.1856
CO2	20.99	440.78	6047	51.68	1.9493
CO3	29.29	858.39	4540	38.80	2.7202
CO4	19.39	376.30	5759	49.22	1.8011
CO5	5.09	25.99	11527	98.52	0.4733
CO6	23.53	553.76	5740	49.05	2.1849

4. Implementation

We have considered two batches of students, say 2014-15 and 2015-16, each batch contains 118 students. Curriculum and the courses are same for both the batches. The course under consideration contains six LOs. Based on the academic performance of 2014-15 batches, we have fixed targets for LOs using the statistical test, and addressed the course outcomes and student outcomes which is probably called as the Student Learning Outcomes (SLO).

4.1 Implementation Results for the 2014-15 dataset

When considering the batch of data corresponding to the academic year 2014-15 the evaluation proceeds for each of LO with respect to the Control Limit (CL), Upper Control Limit (UCL), Lower Control Limit (LCL). The following table 5 provides the observed significant value for the course outcomes with the proposed method over the 2014-15 batches of students.

Table 5 Measurement obtained for 2014-15 batch with the proposed method

Method	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6
$Target\_value = \left(Avg-\sigma, Avg, Avg+\frac{\sigma}{2} \right)$	59	55	57	58	56	56
$Target\_value = \left(Avg-\frac{\sigma}{2}, Avg, Avg+\sigma \right)$	62	66	77	49	48	102

4.2 Implementation Results for the 2015-16 dataset

When considering the batch of data corresponding to the academic year 2015-16 the evaluation proceeds for each of the course outcome with respect to the mean (Control Limit), Upper Control Limit, Lower Control Limit. For this academic year the active learning methodologies such as mini project, and region based case study have been implemented for the subject Information System for the students of second semester. The following table 6 provides the observed significant value for the course outcomes with the proposed method over the 2015-16 batches of students.

Table 6 Measurement obtained for 2015-16 batch with the proposed method

Method	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6
$Target\_value = \left(Avg-\sigma, Avg, Avg+\frac{\sigma}{2} \right)$	61	56	51	62	106	51
$Target\_value = \left(Avg-\frac{\sigma}{2}, Avg, Avg+\sigma \right)$	81	55	51	66	106	56

5. Attainment of SLO from Heuristic to optimal level

At the initialization phase the level of SLO has been fixed heuristically in order to determine its fixed level of course attainment. After the applicability of the measured course outcomes using the proposed strategy the fixation among the SLO values has been obtained. The following table 7 defines the observed SLO from the initial level of heuristic values to the observed fixed level.

Table 7 Attained SLO using the proposed method

SLO	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6
CO Target 2014-15	95	73	68	68	73	104
CO Target 2015-16	84	77	94	71	76	107

The target values has been observed for the two consecutive years and the level of SLO attainment has been fixed from heuristic to measured level. For CO1 alone the attainment value for the 2014-15 batches seems to be high and for the rest of the target values the data corresponding to 2015-16 seems to be the greatest. Hence thereby the fixation of target values is depicted in table 8 as follows,

Table 8 Fixed target values for the course Information Systems

Measurements	CO1	CO2	CO3	CO4	CO5	CO6
SLO	95	77	94	71	76	100

The major consequence is that with the incorporation of Active Learning Strategies (ALS) the improvement in SLO levels has been observed from the two consecutive batches of students. ALS makes the students to learn, think and recognize every module in the courses to be represented in a different way of approach. They can become familiarize in the course modules once they actively participate in any of the strategy that has been followed in correspondence with the modules of the specified subject.

6. Discussion about the incorporation of ALS

A set of two consecutive years of data has been taken for evaluation using 3-sigma level statistical technique. For the dataset corresponding to the year 2014-15, the strategy based upon simple class room level of teaching had been used without any introduction of ALS. For the dataset corresponding to the academic year 2015-16, in addition to the class room teaching, effective usage of ALS and ICT tools such as region based case study with mini project had been used.

The course outcomes for each year for the entire set of students have been calculated. The evaluation proceeds by the determination of the mean, LCL, UCL for each student individually. Then, 3-sigma level computation has been carried out for all the students. When comparing the results of both batches, the students corresponding to the year of 2015-16 seem to produce greater level of attainment in most of the course outcomes rather than the year 2014-15 batch of students. Hence by the usage of ALS in engineering education can spontaneously improve the levels of student attainment at all levels.

6.1 Overall Attainment for the year 2014-15

The overall attainment among the averages of all the course outcomes signifies to a range between 0-20. It reveals that the observed level value falls below the LCL limit which is not suitable value in 3-sigma computation. Hence it won't fall under even within the range of 2-sigma computation. The quantified results provide a mean value of 108 and deviation value of about 25.21 to a smaller specified range. When considering individually the CO3 alone provides a range higher to UCL. The following Figure 8 shows the detailed view for the controls limits for the entire set of course outcomes.

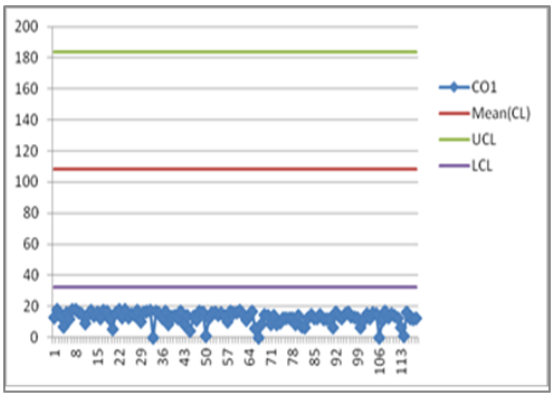

Figure 8 Observed overall attainment value for the academic year 2014-15

6.2 Overall Attainment for the year 2015-16

When considering the dataset of records for the academic year 2015-16 the observed overall 3-sigma computation level lies on the LCL. For the individual set of course outcomes the CO1, CO4 and CO5 provide a value higher to the UCL. The observed mean value is feasible and which is found to be 110 and the deviation is of 31.57 which show that the incorporation of the ALS enhances the ability of the students to a higher level. The overall measures observed to be relevant and the signified value found to be deterministic. The implementation of the active learning strategies has raised the capacity of the students to face the Cos with higher ability than to tackle the basic level Cos. The active learning strategies help in justifying the student outcome levels and further acts as a tool for improvement in the near future. The following Figure 9 provides the control limit levels for the entire set of outcomes.

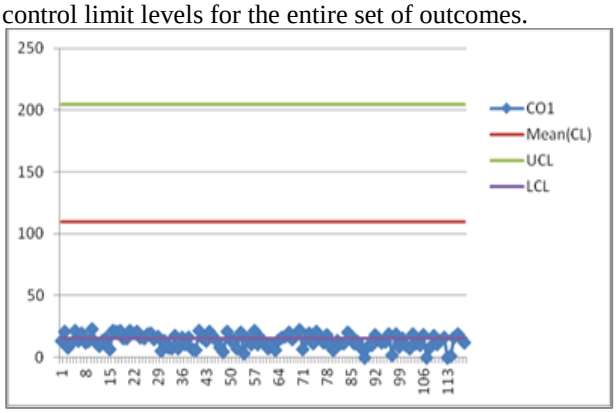

Figure 9 Observed overall attainment value for the academic year 2015-16

6.3 Comparison of the proposed target fixing scheme with the existing schemes:

The proposed technique of target fixing is more efficient than the existing schemes due to the addition of ALS. The application of ALS has significantly improved the performance levels of the data in the current target scheme. The proposed system can be compared with the other existing schemes. The basic target method uses the mean value for fixing the target value. But that has the drawback of not considering the range of the best and the worst case as worst case may affect the average value. The half the distance target method considers the maximum and minimum value for finding the target by adding both and dividing by two. But this also yields poor results when the maximum and minimum values are so far. To eliminate the issues in the existing schemes, the new target scheme is proposed with implementation of the ALS which improves the CO target fixing providing better results for students learning. It is observed that the results have increased numerically to a greater extent by incorporating the new scheme and the efficiency in the system eliminates the students from struggling to learn the subject.

7. Conclusion and Future work

Data analysis plays an important role in all domains of research such as education, health care, data security and so on. The effect of determining useful patterns and relationship paves the way for future value service. Data analysis in education sector provides the usefulness of identifying the improvement and adoption of new strategies towards teaching learning process. This paper conveys the usefulness of statistical techniques in education technology for the determination and adoption of new ICT techniques over teaching learning process. A set of two year data has been considered for students' evaluation using standard deviation statistical technique. Experimental results show that the incorporation of active learning strategies and techniques in engineering education provides the way for improvement in the attainment of learning outcomes. Hence SLO has been determined from heuristic level to optimal level of fixation for the course on information systems. A study over various applications with the evaluation of mini project provides an improvement in learning outcomes beyond the control limit values. Hence the technologies behind ICT tools and ALS can be incorporated over various courses which are relevant to the specific domains can be effectively used.

The future work, focus towards the evaluation of use of different ALS such as Flipped Class room, Quiz, Wikispaces over the higher semester. The real world scenarios, its mappings can be efficiently adopted over the class room teaching which improves the learning capabilities over the students.

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