A Novel Approach for Practical Exam Evaluation Improvement Using DMAIC

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Abstract— ***Programming language based subjects are core to Computer science courses. It is difficult to evaluate programming subjects in exam due to various reasons. There could be many reasons including non-availability of skilled (B Ed. trained) faculty, not enough details in questions or little conceptual mapping found. Six sigma is successfully used in many industry for process improvement in current past. The purpose of this paper is to apply DMAIC methodology of Six sigma to improve evaluation process for programming subject along with rubrics to handle all types of learners. We apply DMAIC methodology to improve evaluation process. We are able to reduce randomness in the evaluation process. Our observations indicate that students' skill levels improved significantly and we can use Six sigma in Education areas.***

Key words: Six sigma, Rubric, Learning Style, DMAIC, Process Improvement

I. INTRODUCTION

Number of institutes and courses have grown drastically in past few years [21].Programming language is a core part of Computer science program syllabus. Key objective of all programming language based courses is to teach programming concepts to students.

Generally, Practical subject evaluation is consisting of two part: programming and viva. Low results / placement data shows that students are facing difficulty in acquiring programming skills and scoring good marks [1, 2].

The key problem areas are: a) Questions given to students during exam are found to be in brief i.e. in few lines e.g. 3-4 liner. As a result, student either does not visualize what to be done or do bare minimum as a result of lack of information. b)Every students are different [32, 33]. The key three categories why students are different are: i) students' learning styles (characteristic ways of taking in and processing information), ii) approaches to learning (surface, deep, and strategic), and iii) intellectual development levels (attitudes about the nature of knowledge and how it should be acquired and evaluated) [32]. c) Most of faculty have not undergone formal educational training for teaching.

In the recent past Six sigma is used in various industries for process improvement and reducing variation [17],[20]. Six sigma has two methodology, Define Measure Analyze Improve and Control (DMAIC) and

Define Measure Analyze Design Verify (DMADV). Earlier one is used to improve existing process while later one is used for new process definition.

For investigation of this problem, we have used data from Gujarat Technological University of Master of Computer Applications (MCA) course.

This paper explores the application of DMAIC methodology to improve Practical Exam evaluation process. We have implemented templates in various subjects and results were compared.

The rest of this paper is organized as follows.

- Section II, briefly describes the literature review
- Section III briefly describes problem statement
- Section IV describes Research question and gaps
- Section V and VI briefly describes proposed Solution using DMAIC.
- Section VII describes. Experimental results and Feedback from students and Faculties
- Section VII includes conclusion

II. LITERATURE REVIEW

a) Quality
The key factors affecting poor quality are; People, Process and Technology as suggested by author of [7] and [8].

b) Process Improvement
Philip Crosby says "Quality Is Free" [7] means it's cheaper to do things right the first time, however it always costs more to have to go back and fix something. And process improvement is all about getting it right the first time (FTR) [9].

Why to improve existing process?

a) Once a process is defined and implemented, it should yield similar results except for exception cases. If we get different results on each run means there is a variation
b) If one can run it successfully, anyone should be able to repeat it.

The idea behind process improvement is to capitalize on that success or to institutionalize success as much as possible.

c) Six sigma

Six Sigma is a process improvement methodology developed by Motoroala(www.motorola.com) to improve process capability up to 99.9997%[9].[10] and [11].

Six Sigma has two key methods, both inspired by Deming's Plan-Do-Check-Act Cycle) [3]:

1. For existing process: DMAIC (Define, Measure, Analysis, Improve and Control).
2. For new process: DMADV (Define, Measure, Analysis, Design, Verify). It is also called as DFSS.

d) DMAIC

DMAIC (Define-Measure-Analyze-Improve-Control) is one of the Six sigma methodologies used used to improve and control quality of existing product or services.

The methodology indicates the project be *defined* to ensure that it remains profitable while reaching the Six Sigma level of quality, all defects are *measured* and *analyzed* so that they are eliminated. Once defects are eliminated, we can conclude that the quality is i*mproved*, the next step is to make sure the *control* mechanisms are there to continuously guarantee the quality of products and/or services[20].

DMAIC is widely used for performance and quality improvement in many areas. Like HR [13], banking [14], service industry [15], manufacturing [16] etc. for process improvement

e) Why DMAIC?

DMIAC is right choice for this project because *Six sigma's principle and goals "standard process, continuous process improvement" are similar to the goal of this project[3]*

f) Learning and Teaching

Practical exam question are a special type of questions.

According to Richard Felder, Students are different.

This paper represents the application of Six sigma DMAIC in Academic Scheduling for process improvement using Rubrics.

III. PROBLEM STATEMENT

Education quality is crucial for world economy. Having good process in place is not enough [7, 8, 9, 10, 11]. One must execute and implement process effectively and improve process continuously [23, 24].

Principle of "Mastery Learning" suggest that students can score high grades / marks if they are provided enough time to learn and via quality instructions [25]. High quality instruction can be achieved using proper format / template and rubrics [25]. Learner can easily understand problem if question or material is having good rubrics [4].
Major challenge in teaching is existence of different learner style within group of students i.e. each student is different [5, 6]

As per bloom's taxonomy, to achieve high score one need to gain knowledge, understanding or organizing concepts for all three domain respectively[5, 6].

One of the two major problem with teaching programming subjects to student is how to assess how well they have mastered [26].

Unless one visualize what need to be achieved it is harder to write a program [26]. It is equally important to implement logic using programming concepts. Rubrics are successfully used by various universities for improving students skills and evaluation [28, 29].

Visualizations is best way to accomplish this as it increases understanding and assists in learning the abstract and complex concepts of the domain [30].

There are many types of learners in the same division [27]. Also, it is one of the biggest challenge in teaching is to address all types of learners [27].

We summarize following quest for improving quality of education [4,24, 25, 26, 28, 29, 30]: 1) Researchers have provided various pedagogical solutions, which can be used for improving quality in education 2) Classify students based on learning style and address them separately 3) Using scientific and systematic methods and tools one may address most learning styles.

IV. RESEARCH QUESTION

Research Question	How to minimize evaluation randomness
Objective	How to improve effectiveness of practical subject evaluation?
Variable Studied	Programming Languages Concepts Industry Requirements Course Content Business Program Logic
Resources	Dean, Subject Expert, Students
Scope In	Practical Exam Evlaution
Scope Out	Theory Subjects (Linked or non-linked)

Major gap found in practical questions are: 1) In adequate Topic Coverage 2) Missing clarity for development 3) Missing clarity for evaluation

V. EXPERIMENT: RUBRIC BASED QUESTION TEMPLATE

Six Sigma DMAIC road map is used in improving Practical exam evaluation process using DMAIC. Each phase is described in the sub sequent sections

5.1 Phase I; Define

Six Sigma methodology begins with identification of problem. The first step in method is to listen Voice of customer. The define phase narrates a)current process, b)the problem statement, and c)the goal (generic and business)..

5.1.1 Set project goal and initiate Project

Project Charter for the Six sigma project looks like:

Project Title	Reduce Practical Exam Evaluation Randomness
Customer	Gujarat technological University
Problem Area	**Question clarity** **Reduce evaluation randomness**
Goal	Under normal conditions results of interlink practical subjects should not have high variation.

5.1.2 Define Project

Customer	Gujarat technological University
Problem Statement	Process improvement: i) Question Rubrics ii) Evaluation random ness
CTQ	Every time the questions designed should have clarity and illustration and evaluation should not be random
Business Goal	quality of question and Evaluation
Y Measure	Each exam question generation request
Big Y	Question consistency
Core Process	Practical Exam Evaluation

Every time the requirement of Customer (Dean,) is to have different questions for exam. However, common in every request is ambiguity reduction, decision support information and better quality.

Focus: Coverage and Rubrics	
Scope In	Practical Question set Creation
Scope out	External factors like Programming language / software version Theory Exam / paper

We will use SIPOC (Suppliers, Inputs, Process, Outputs, Customers) to define current process.

For Suppliers and Customers, key stake holders involved in day-to-day operations of college/institute considered. Top-level management is not considered for this paper.

SIPOC: Current Process

Suppliers	Dean, Subject Experts
Inputs	1) Syllabus 2) Teaching scheme
Process	1)Search Subject Expert data for question set preparation 2) Assign Task
Outputs	Practical Set
Customers	Dean , Exam Controller, Examiner, Subject Experts

5.1.3 : Identify Team

Green Belt	Jignesh Doshi
Critical Support	Maxwell Christian Bhushan Trivedi
Sponsors	Controller of Examination

5.1.4 : Define Charter Plan /Timeline

Phase	**Completion Date**
Define	01-JUL-11
Measure	01-OCT-11
Analyze	01-NOV-11
Improve	01-JAN-13
Control	01-MAY-13
Close	01-AUG-13

5.2 Phase2: Measure

The measure phase is critical in order to improve process. During this phase we will identify what to measure and how to collect data. Key steps of measure are;1) identification of measures 2) Define data collection process 3) Collect data.

Output of this phase is the current process capability. Generally in six sigma it can measure by using z score.

Y Measure	Each Question Set Generation request
Big Y	Question consistency
Defect	Ambiguity in Question
Defect Opportunity	Every Semester Exam Schedule
Data Collection	Data collected for each Exam
Period	01-aug-11 to 05-dec-11
Data Points	Number of times job ran during this period

Before Improvement Result Data

Theory Result (%)	62%
Practical Result (%)	89%
Variance	27%

5.3 Phase 3: Analyze

Measure phase provides data which are facts. Key steps of analyze phase are;1) analyze data and identify root causes 2) device alternatives 3) select best one

To identify root cause and prioritize it, pareto principle is often used for it.

Exhaustive list of root causes for the identified problems are:

No clarity in Question

2) Students having different understanding
3) Imbalance topic coverage

Prioritized root cause: No clarity in Question and imbalance topic coverage

Action Plan:

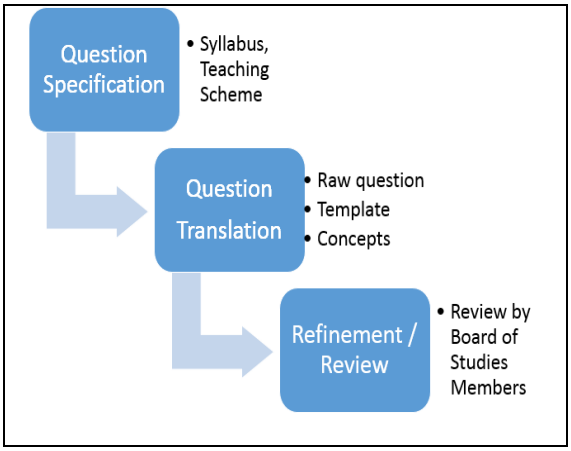
Create Template with Rubric to implement question with programming concepts and process automation.

5.4 Phase 4: Improve

For the selected alternative (prioritized root cause), the proposed process map is prepared in the improve phase.

Process Flow:

Question setting with rubric is a 3 steps process.



Process steps are explained as below:

1) Question Specifications: Identified subject expert will download syllabus and teaching scheme form university web site.
2) Template Translation: Identified subject expert is provided with template, guidelines and raw question. He/she will translate question.
3) Refinement / Review: Prepared questions are sent to board of studies members for reviews and refinement is done (if any).

Here complex question can be tackled using exhaustive rubrics and concepts to define standard process. .

Current process improvement listed in below SIPOC.

SIPOC: Proposed process

Suppliers	Faculty, Subject Expert, Dean
Inputs	1) Syllabus 2) Teaching Scheme 3) Template with rubrics
Process	Identify subject expert from Faculty Data Provide Syllabus, Template Prepare Question set
Outputs	Practical Question set
Customers	Examiner, Subject Expert, Dean

5.5 Control

Control phase standardize improvement made in the current process. Key steps are 1) The new process pilot 2) Document process 3) Validate process 4) Train subject experts 5) Verify results.

After preparation of Templates, the Question sets prepared using templates were implemented for 2 consecutive semester and results data was collected form University portal / web site.

Data to monitored	Each semester exam
Defect	Result of Theory and Practical
Data Collection	Results of each Exam
Pilot	05-jan-13
Period	10-jan-13 to 12-Aug-13

VI. PRACTICAL QUESTION SET

The raw question looks as below:

Write a C++ program that performs the Quick Sort. [80]

The above raw question after translation using template and implementation of rubrics will be as below:

1. Write a C++ program that performs the following tasks:

   1.1. Create a class called QuickSort with the following data members: [10]
   - 1.1.1. A pointer to store dynamic array of whole numbers
   - 1.1.2. A variable to store the size of the array
   - 1.1.3. A variable to store the count of the elements stored in the array

   1.2. Design appropriate constructors to create objects in following manner and initialize members as required [10]
   - 1.2.1. QuickSort obj1 ; // Object with default size
   - 1.2.2. QuickSort obj2 (5) ; //Object with size of 5 elements

   1.3. Overload the << and >> operators to input and display the contents of the object. Following are samples to use the overloaded operators [20]
   - 1.3.1. cin >> obj1 ; // Inputs one value at a time in the object
   - 1.3.2. cout << obj1 ; // Outputs all the values stored in the object

   1.4. Design appropriate destructor to avoid memory leak [10]

   1.5. Provide a member function which sorts the elements of the member array in ascending or descending order using quick sort method [30]

VII. RESULTS

Results After for interlinked subject

	Before	After DMAIC Improvement	
	Before	Exam 1	Exam 2
Total Students	618	677	746
Theory Result (%)	62%	74 %	70 %
Practical Result (%)	88%	82 %	75 %
Variance	26 %	08 %	05 %

For this paper, we have developed google online feedback form. The responses are as below:

A) **Student Questionnaire Feedback**

Question	Description	Agree	Dis Agree
1	In new Question style, I know better what I am suppose to develop	185	10
2	I am more clear about the evaluation process now	183	12
3	Problem definition is more clear	183	12
4	Help us in scoring high	180	15

B) FACULTY QUESTIONNAIRE FEEDBACK

		Agree	DisAgree
1	Is question more readable?	24	0
2	Does question in new style increased evaluation consistency across examination centers?	20	4
3	Does the structured program help in increasing evaluation consistency across different examiners?	18	6
4	Does the structured question help students to understand the exact requirement easily?	24	0

VIII. CONCLUSION

In this experiment, we evaluate the potential of DMAIC methodology to improve evaluation process. First, we identify key root cause for the said problem. After identifying problem area, we rectify it using action plan. We implemented solution for 3 semesters and observed results.

What we discovered is that the variance between theory and practical subject evaluation has reduced. We get results in academic which is similar to what Six Sigma gave in manufacturing industry [15]. so we can conclude that we can apply Six sigma methodologies to non-manufacturing area like Academic.

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