ANNEXURE-VIII

Blooms Taxonomy of Cognitive Domain. (LOTs and HOTs)

Blooms Taxonomy of Cognitive Domain was developed by Benjamin Bloom in the 1950's. Blooms Taxonomy was developed to express different kinds of thinking. It is useful within the classroom to use as a tool for planning, and is one of the most universally applied models. Blooms Taxonomy provides a way to organize thinking skills into six levels from the most basic to the more complex levels of thinking.

The revised version of Bloom's Taxonomy of the cognitive domain consists of six different levels of learning objectives listed in sequential order of increasing difficulty. The cognitive domain of learning is concerned with the acquisition and application of knowledge and skills; each level of Bloom's Taxonomy reflects increasing difficulty of the cognitive domain. The levels of Bloom's Taxonomy, in order, are: **remembering, understanding, applying, analyzing, evaluating, and creating**. Levels at the top of the list are often considered lower ordered thinking (LOT), while those near the end of the list are considered higher order thinking (HOT). LOT and HOT relate to the lesser and greater amount of cognition involved in learning at the six levels of Bloom's Taxonomy.

The Revised Terms of Bloom's Taxonomy:

- **Remembering**: Retrieving, recognizing, and recalling relevant knowledge from long-term memory.
- **Understanding**: Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.
- **Applying**: Carrying out or using a procedure through executing, or implementing.
- **Analyzing**: Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing.
- **Evaluating**: Making judgments based on criteria and standards through checking and critiquing.
- **Creating**: Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.

Lower Order Thinking (LOT):

Lower-level thinking is the lower level of Blooms Taxonomy. It's embodies the level of skills necessary for advancing through the higher levels of Bloom's Taxonomy. The skills acquired at this level, are the building blocks toward higher level thinking.

LOT promotes:

1. Remembering 2. Understanding. 3. Applying

Higher Order Thinking (HOT):

Higher Order Thinking takes place in a hierarchy of cognitive process. It is a continuum of thinking skills starting with knowledge level thinking, and moving to evaluation thinking.

HOT promotes:

1. Applying (there is a fine line, or grey area, in this level where lower level cognitive thinking begins to transition to higher level cognitive thinking.)
2. Analyzing 3. Evaluating 4. Creating.

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 6, June - 2014

Improving Teaching - Learning Process using Bloom's Taxonomy and Correlation Analysis

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***Abstract*— Bloom's Taxonomy can be used to understand and measure how much critical thinking skills developed in a student. Educationalists in past had suggested to apply bloom's taxonomy to improve student's performance in a course. This paper will investigate the impact of bloom's taxonomy in introductory computer programming course to improve student's learning experience and performance. Result from controlled experiment shows that by applying Bloom's Taxonomy in Teaching-Learning process improves the performance of students significantly by providing an appropriate feedback(s) to the instructor about student's progress in their course. This helps instructors to concentrate more on the area(s) where students are weak in their course as compared to the students learning with traditional in-class teaching methodology. The Text extraction and Text classification algorithm is introduced in this paper. Pearson's Co-relation analysis performed using IBM SPSS tools to find out the relationship, if any, among the various levels of Blooms Taxonomy.**

Keywords*— *Bloom's Taxonomy, Correlation Analysis, Teaching-Learning, Text classification, Text extraction.

I. INTRODUCTION

The primary focus of education and class room teaching should be on mastery of subjects and the promotion of higher forms of thinking, rather than simply an approach of transferring facts. As a teacher, we ask many questions to our student every day. All these questions are not from the same level. It is been observed that some questions are very easy to answer at the same time some questions may require a great deal of thinking.

In class, teaching has an objective to aid students with better understanding of concepts and to escalate their thinking abilities in a course. Due to high number of students and lack of time for instructors in each class, instructor fails to ask about performance/issues from each student in their course. Sometimes students repeat the answers of other students, in such a situation it becomes very difficult for a teacher to evaluate the students. There"s no empirical evidence to show that an instructor could track the performance of students without physically communicating with them one-to-one. In 1956, Benjamin Bloom and his colleague"s give the Taxonomy, which can be used by a teacher to frame the questions, so that maximum learning happens by the students, this taxonomy is known as Bloom"s Taxonomy. It is a classification of educational objectives [1].

II. BLOOM"S TAXONOMY

Benjamin Bloom has given six different levels of cognitive stages in learning. The lowest level is the simple recall or recognition of facts, through increasingly more complex and abstract mental levels, to the highest order. At each level Bloom defined some keywords which can be used to frame the question as per different cognitive levels of Taxonomy. Taxonomy is revised by his student Anderson in 2001[2]. Anderson made some significant changes to original Taxonomy. New levels are renamed as Remembering, Understanding, Applying, Analyzing, Evaluating and Creating.

The six levels of Bloom"s Taxonomy are:

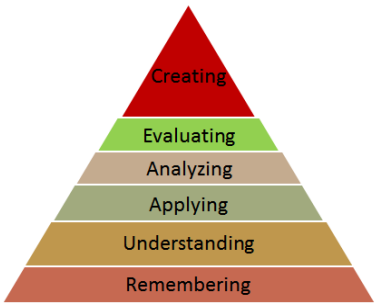

Fig. 1. Bloom"s Taxonomy

- **Remembering:** Whether the student can recall or remember the information(Keywords: list, define, name, state, describe, recall, tell)
- **Understanding:** It might possible that student know the facts but whether he has actually understand the meaning of the information or he/she is able to explain ideas or concepts(Keywords: explain, translate, summarize, classify,)

- **Applying:** Whether the student is able to apply what he/she knows in a real situations? (Keywords: apply, solve, modify and illustrate)
- **Analyzing:** Can the student distinguish between the different parts? (compare, differentiate, distinguish, examine)
- **Evaluating:** Is the student able to justify a piece of code or select from the alternatives available? (Keywords: evaluate, select, judge, decide)
- **Creating:** Can the student create new product or point of view from the things he has understood? (Keywords: create, develop, combine, re-write)

I. RELATED WORK

Johnson, Fuller[3] and a team of academic colleagues examined the question „Is Bloom"s Taxonomy Appropriate for Computer Science?". Author [4] has published the work and discusses each of the Bloom classification categories and provides a consistent interpretation with concrete exemplars that will allow computer science educators to utilize Bloom"s Taxonomy for programming assessment. Assessment plays an important part in the teaching learning process at all levels of education. The main purpose of classroom assessment is to improve learning [5]. Traditional in class assessment techniques are time consuming and require more efforts.

The hierarchical model of Bloom"s Taxonomy is widely used in education fields [6]. Chang and & Chung presented an online test system to classify and analyze the cognitive level of Bloom"s Taxonomy to English questions.

Nazlia Omar and his colleagues [7] have categories the exam question based on Bloom"s Taxonomy "Automated Analysis of exam questions according to Bloom"s Taxonomy"**.** The author proposes an automated analysis of the exam questions to determine the appropriate category based on this taxonomy using natural language processing. The work focuses on the computer programming subject domain. Their rule-based approach applies Natural Language Processing (NLP) techniques to identify important keywords and verbs, which assist in the identification of the category of a question.

II. PROPOSED FRAMEWORK

This section describes the complete working of the proposed framework in detail.

A. Preparating the set of exam questions:

In these work, thirty programming question from C++ programming language were selected. From each level five questions were selected. These were the multiple choice questions. Each question contains some keywords as per the keywords suggested by Bloom for framing the questions at each level, i.e.

List the keywords available in C++ language.

In above question four options were prepared out of which one was correct. As above question contains the keyword List, which belongs to remembering level.

B. Text Extraction and Classification:

An online framework is developed where, questions are being classified automatically when questions are added to framework. For these purpose text extraction and classification algorithm is developed. The keywords from the question are extracted and then compared from the keywords saved in database for respective levels. If the extracted keyword matches the one which is saved in database then that question categorizes into that level.

The questions are added to database one by one. While adding, the text extraction system extracted the keywords and stored them in to an array. The levels and corresponding keywords are then retrieved from database. For each level the corresponding keywords are matched with the extracted keywords stored in array, if there is a match then that question allotted to that particular level. The whole process is given in text extraction and text classification algorithm.

Algorithm:

```
set variable level to null
read inptut qustion into variable Q
read levels L and corresponding keywords K from database
 for each level L and keywords K in L
  do
     split question Q and store in array W[ ]
     spilit keywords K and store in array k[ ]
     for each keyword k in array k[ ]
      do
       for each word w in array w[ ]
       do
            if keyword k is equal to word w ,then
              set level = L
              set question level to L in database
          end if
   end for
  end for
end for
```

C. Conducting the Online Exam

After adding all the questions, the framework is tested on total of 49 students of computer science and engineering second year students. The students register themselves on framework and took part in test. They answered all the questions one by one. At the end of the test, their individual score card is generated and shown to them. After evaluating the result, the students came to know about their strengths and weaknesses in each level of Taxonomy. After analysis of overall class result students and instructor came to know that there are some students which are very good in some level, while they are very weak in other levels.

Final score of all the students is calculated and exported in to excel data sheet for further processing. Next, to find the relationship between different levels correlation analysis is performed using the IBM SPPS Statistics Tool, in SPSS Pearson"s correlation is applied.

D. Interpreting the individual student result:

The result generated after completion of test of one student is show in Fig. 2. The chart shows the marks obtained by a

single student in different level of Bloom's Taxonomy. It is clear from the result that the student is good in remembering level, means he/she can remember the things taught in a class. His understanding level is not that much good, and he is also not able to apply the facts and the things which he has understand. He is quite good in analyzing and evaluating the things. And in creating level he has also score very less marks. So, overall he needs to improve applying, understanding and creating level. If he will improve understanding and applying level, the creating level will automatically get improved.

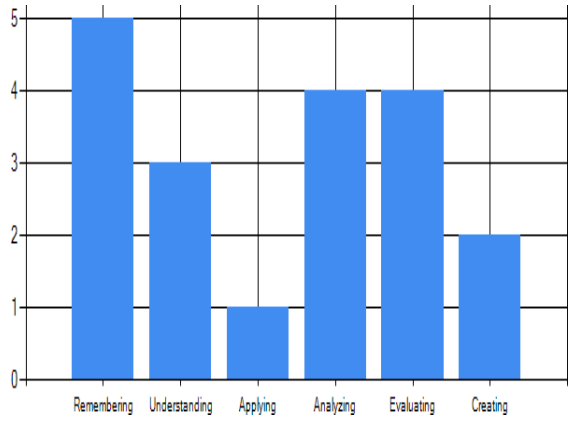

Fig. 2. Individual student result

A. *Interpreting the class result:*

Fig. 3 shows the overall performance of the whole class in a test. It is clear from the class result that most of the students are good in remembering. Some students are good in analyzing and evaluating. The understanding and creating level of all the students in a class is very weak. If someone has not understood the actual meaning whatever was taught in a class, then he/she can not apply that in a real situation. Similarly if someone is not able to apply, he/she cannot be so creative in programming. So, from overall class result it is very clear for the teacher of the class, that he/she should concentrate more on understating, applying and creating level. He should ask question in a class which emphasizes more on these levels.

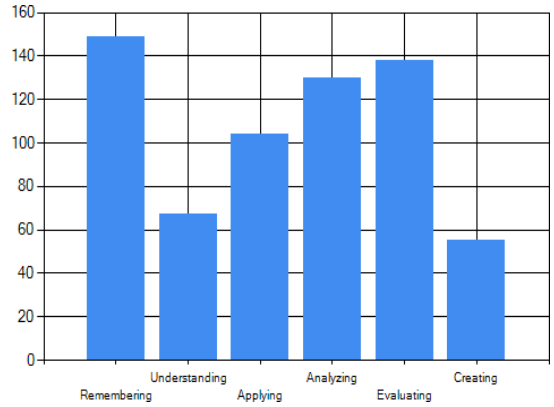

Fig. 3. Overall class result

B. *Architecture Diagram*

The complete working of the framework is summarized in architecture diagram, Fig. 4.

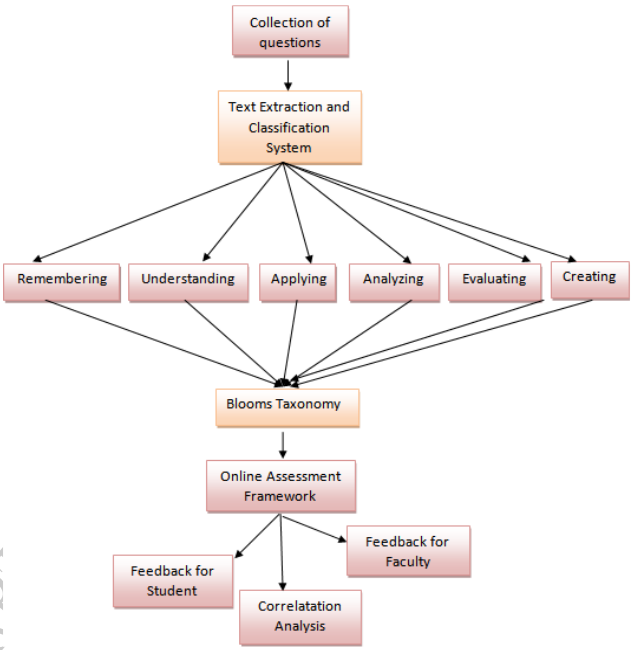

Fig. 4. Architecture diagram

From architecture diagram the notable points are:

- Collection of questions is perfomed
- Text extraction and classification system categorizes all the questions as per the levels of Taxonomy
- Online assessment framework produces the appropriate feedback in form of result to students and teacher, and correlation analysis identifies the relationship among the levels of Taxonomy

I. TOOLS AND TECHNOLOGY USED

This section describes the tools and technology used to develop the framework in brief.

ASP.NET 4.0

ASP.NET is used by the programmers to build server side web applications and web services. ASP.Net support many languages which are built on top of .Net framework.

Microsoft C#:

Microsoft C#(C Sharp) is a strongly typed, multi-paradigm, object oriented, simple and modern general purpose programming language which supports .NET framework. It

supports exception handling, multithreading and all other object oriented features.

Microsoft Visual Studio

Visual Studio is an Integrated Development Environment. It has many unique features which helps the programmer in creating any .Net application.

Microsoft SQL Server

MS SQL is a Relational Databse Management System (RDBMS) developed by Microsoft. It is one of the most popular database management systems available. MS SQL server is highly reliable, fast and easy to use. It has a simple and user fiendly environment for creating and manipulating database, and integrating with Visual Studio.

Microsoft Chart Controls 4.0

Microsoft chart controls are used to generate the different charts. It offers a wide variety of charts to select the one which user requires for viewing the data in chart form.

I. CORRELTION ANALYSIS

IBM SPSS Statistics Tool is used for correlation analysis, it is a software package used for statistical analysis.

Pearson Correlation:

It measures the degree of the linear relationship between two variables. By linear relationship we mean that the relationship can be well characterized by a straight line. Positive correlation means higher score on variable A are associated with higher score on B, also true for lower values. Negative relationship means higher scores on A are associated with lower scores on B. The correlation coefficient r may take any value from

$$-1.0 <= r <= +1.0$$

For interpreting the result hypothesis have been made that students those who have score less marks in understanding level, have also score less marks in creating level. So we can say that there is a positive correlation between these two levels.

The value of correlation coeffiecient between understanding and creating level is .566, and the correlation is significant at 0.01 level. We can conclude that there is a statically significant correlation between understanding and creating level. Students whose understanding level is good are also good in creating level, and students who are weak in understanding are also week in creating level.

Table- 1. Pearson Correlation result

Correlations

		Understanding	Remembering	Applying	Analyzing	Evaluating	Creating
Understanding	Pearson Correlation	1	-.028	.126	.161	-.095	.566**
	Sig. (2-tailed)		.851	.389	.270	.517	.000
	N	49	49	49	49	49	49
Remembering	Pearson Correlation	-.028	1	.162	-.140	.089	.236
	Sig. (2-tailed)	.851		.266	.336	.544	.103
	N	49	49	49	49	49	49
Applying	Pearson Correlation	.126	.162	1	.235	.142	.171
	Sig. (2-tailed)	.389	.266		.103	.330	.240
	N	49	49	49	49	49	49
Analyzing	Pearson Correlation	.161	-.140	.235	1	.125	.181
	Sig. (2-tailed)	.270	.336	.103		.394	.213
	N	49	49	49	49	49	49
Evaluating	Pearson Correlation	-.095	.089	.142	.125	1	.123
	Sig. (2-tailed)	.517	.544	.330	.394		.399
	N	49	49	49	49	49	49
Creating	Pearson Correlation	.566**	.236	.171	.181	.123	1
	Sig. (2-tailed)	.000	.103	.240	.213	.399	
	N	49	49	49	49	49	49

**. Correlation is significant at the 0.01 level (2-tailed).

Another hypothesis have been made that students who get good marks in remembering level also score good marks in evaluating level, it is also a positive correlation with correlation coefficient value of .544, but the correlation is not significant.

CONCLUSION AND FUTURE WORK

This paper presents the automatic classification of exam questions as per the Bloom"s Taxonomy and produces the feedback to student and teacher which improves the overall teaching-learning process. The framework is able to extract the questions and then categorize them into appropriate level as per the Taxonomy. The framework is tested on students to identify the cognitive level of the students. After appearing in the test, students get their result in form of charts. Overall class result is generated for all the appearing students, which helps in deciding/changing the strategy for a teacher so that maximum learning happens in a class. Pearson"s correlation is performed using IBM SPSS statistics tool to identify linear relationship between different levels of Bloom"s Taxonomy. The instructor of the class can make the decision after reviewing the correlation results and accordingly he can decide his strategy. The overall Teaching-Learning process is improved with respect to individual student result and overall class result.

In future, categorization of students according to the wrong answers given by them in level or question and automatic text suggestion as a feedback for student and faculty emphasizing what action they should take will be done.

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