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Adoption of Bloom Taxonomy in Automated Question Answering in E-Learning System

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Abstract-**At present, with the growing demand of knowledge economy, fast popularization and development of the World Wide Web, a lot of people are turning to e-learning via web particularly in educational institutions. There are plenty of e-learning systems nowadays and these systems provide functionalities ranging from some simple tools to manage and search a lot of teaching materials to knowledge sharing through online forum discussion. While the online forum discussion promotes exchanging ideas between instructors and students, however due to the job demand of instructors at their workplace and at times being away from their workplace would often result in responses to the students' questions were not being responded in time. To address the problem, automated response systems in forum discussion have been developed where the system would take the responsibility to respond to questions posed by student in forum discussion in the absence of instructors thus reducing the workload of instructors significantly. Despite some research work has been revolved around automated response system in forum discussion in e-learning system, the extent to which the depth of responses or knowledge in accordance to Blooms taxonomy has not been fully explored. Equally important, besides matching keywords of questions to generate responses is the ability to provide adequate details of knowledge to a particular question in the order of depth of knowledge in the context of Blooms taxonomy. This paper will highlight an integrated approach to extract relevant knowledge in accordance to Blooms taxonomy from learning materials particularly in forum discussions (software forum threads) in response to questions posed by learners. As a result, an enhanced architecture of question and answering system in the context of forum discussion would be proposed. Also will be discussed are the technologies such as text mining, data mining and artificial intelligence to accomplish the proposed tasks. On completing the suggested tasks, a more intelligent automated response system in accordance to Bloom taxonomy can be produced.**

Keywords-**E-learning, ontology, Bloom Taxonomy, forum**

I. Introduction

A paradigm shift in the digital era has seen major improvements in the network communication area by leaps and bounds; resulting e-learning technology became a household term in many high schools and tertiary educations around the world. It has become an integral part in teaching. And this is evidenced by widespread adoption of e-learning by many educational institutions and organizations. With the advent of the technology, more and more people recognize that it has the ability to overcome the obstacle of geographical location and time, promote knowledge, skills learning and personalization. It also offers learning-on-demand and reduces the costs and time of learning [1].

Collaborative learning in e-learning is indisputable with the presence of online forum discussion where it can foster sharing of knowledge between learners and instructors. Due to considerable work which plaguing learners nowadays, they are grappling with incessant questions posed by learners in forum discussion which resulting in responses to questions were not delivered in a timely manner. The emergence of automated question and answer system in forum discussion alleviates the problem to a certain extent. Apparently there have been some research works in place to address the problem though there are other potential aspects in automating responses in forum discussion which have not been fully

explored. As foolproof as the existing Q & A systems in forum discussion may appear, however, the inability to extract the extent to which learners expect from responses to questions in respect of depth of knowledge in accordance to Bloom taxonomy is apparent in the current system. As a result of this, learners might have to repetitively pose questions to the automated Q& A to meet their expectations. Besides matching questions from learners with the existing categories/keywords stored in knowledge base, equally important is to identify the desired depth of responses expected by learners which is able to minimize the number of inter-related questions.

Finding relevant knowledge in forum discussion in accordance to Bloom taxonomy is rather challenging as within a forum, there are many threads. And in each thread, there are many posts. Software forums contain a wealth of knowledge related to discussions and solutions to various problems and needs posed by various learners[2]. Compounding further is that the wealth of information is in a textual and unstructured form. In viwe of this, an appropriate approach has to be in place to retrieve only relevant knowledge in accordance to Blooms taxonomy.

II. Literature Review

Widespread adoption of e-learning system in universities and in companies is indicative of how important and significant the technology is in developing human capital. And this is made possible with the advent of online e-learning discussions or forums which can serve as important source for deriving knowledge in e-learning systems. Improving the effectiveness in discussion forums in respect of conversation among users in e-learning environment can encourage more users to participate in it [3].

There has been a continuous growing demand in the utilization of online forum discussion since a decade ago and this has led to creating an automated question and answer forum discussion. Conversation in an interactive way between learners and instructors using Naive Bayesian Classifier [4]is one of the initiatives in automating responses in forum discussion. While this research work is interactive which works like chatbot and has the ability to convert text to speech, however, there is no much evidence as to how questions from learners are used to identify the level of details in accordance to Bloom taxonomy that they are seeking for. Collaborative learning through e-learning is certainly can enhance knowledge sharing to a greater extent and this is an integral part of the research work done by [5]. And the research work is very much focused on using semantic approach to facilitate collaborative e-learning where matching of questions with the database and retrieval of its relevant responses were made easy. When automated answering system first was introduced in e-learning system, much of research work has been devoted to improving the accuracy of answering user's question and the work by [6] which uses WSD (Word sense Disambiguation) approach is critical for correctly retrieving the answer for user's question which is different from their work as this paper emphasize incorporating Bloom taxonomy to meet learners expectations.

Despite some research work has been revolved around in e-learning in respect of automating answering system in **forum discussion**, there is no evidence showing if responses to questions posed by learners are sufficient in the **context of Bloom taxonomy**.

Bloom's taxonomy was first described as a hierarchical model for the cognitive domain in 1956 [7]. The model was revisited in 2001 by Anderson and a team of cognitive psychologists. As a result, a number of significant changes were made to the terminology and structure of the taxonomy [8]. These two versions of the taxonomy of educational objectives are often referred to as Bloom's taxonomy [7] and the revised Bloom's taxonomy [8].

Bloom's Taxonomy of Educational Objectives [9] is a well-documented and useful tool for analyzing education outcomes in the cognitive areas of remembering, thinking, and problem solving. Designed to aid in stating meaningful objectives and raising intellectual levels, the Taxonomy is identifies six categories (see Figure 1) where the higher levels include all of the cognitive skills from the lower levels.

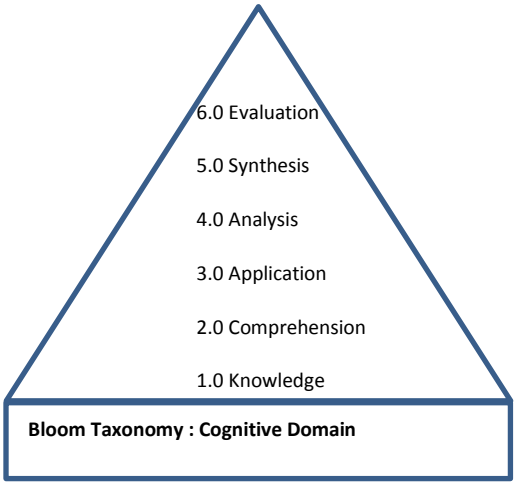

Figure 1: Bloom Taxonomy

Following are definitions and illustrative terms that depict Bloom's cognitive taxonomy:

1. Knowledge: remembering previously learned material, recall facts or theories; bring to mind.
Terms: defines, recognizes, memorizes, describes, inquires, recalls, identifies, lists, matches, names.

2. Comprehension: grasping the meaning of material; interpreting (explaining or summarizing); predicting outcome and effects (estimating future trends).
Terms: convert, defend. distinguish, restate, infer, interpret,estimate, explain, genemlize.

3. Application: ability to use learned material in a new situation; apply rules, laws, methods, and theories.
Terms: changes, computes, sketches. practices, illustrates, calculates, demonstrates, shows, uses.

4. Analysis: breaking down into parts; understanding, organization, clarifying, concluding.
Terms: distinguishes, diagrams, outlines, relates, compares,diagrams, experiments, tests, discriminates, subdivides.

5. Synthesis: ability to put parts together to form a new whole; unique communicator - set of abstract relations.
Terms: combines, complies, rates, revises, scores, selects,composes, creates, designs, re-arranges.

6. Evaluation: ability to judge values for purpose; base on criteria support judgment with reason (no guessing).
Terms: appraises, criticizes, compares,supports,manipulates. concludes, discriminates. contrasts.

The significance of Bloom's taxonomy in education domain is undisputable as evidenced by the work of [10] where it has been applied in computer science for course design and evaluation. It also has been used in comparing the cognitive difficulty level of computer science course [11]. As it has been an integral part in assessment of learners in educational institutions, a lot of research work have been carried out to incorporate Bloom's taxonomy into e-learning system. Identifying specific knowledge in accordance of Bloom's taxonomy in learning materials would ease learners to retrieve the required knowledge expected by them. The work by [12] enables automatic annotation of pedagogical characteristics for learning materials. This work proposes methods to identify four types of documents such as explanation; application; experiment and exercise type based on Blooms taxonomy and the work is intended for identification purposes of learning materials and does not in any way related automated responses for learners. Related work led to an approach to annotate and retrieve learning materials based on ACM classification [13]. This approach proposes a ranking algorithm to find the relevance of the document compared with concepts in ACM ontology. This work is very much focused on retrieving learning materials such as slides, documents and etc. In pursuit for higher accuracy for identifying relevant knowledge in learning materials resulted in the research work by[14]. It is to increase the effectiveness of personalized delivery of learning materials by adopting all six categories of Blooms educational taxonomy and using natural language processing to extract domain vocabularies and link with contextual concepts. Despite much research work has been done by bringing Bloom taxonomy into e-learning with the intention to identify and to retrieve specific knowledge for learners, it lacks interactivity aspect in retrieving relevant knowledge in accordance to Bloom taxonomy for learners in online forum discussion. Recent research work by[2] improves finding relevant answers from software forums in search engine but it can be further improved by incorporating Bloom taxonomy to find relevant knowledge.

Hence, this research work is aimed at increasing the effectiveness of retrieving specific and relevant knowledge in accordance to **Bloom taxonomy** from a pool of **past responses** in online forum discussion in an **unstructured form** for questions posed by learners in an interactive manner.

III. Methodology

Architecture of the Question Answering System

The architecture of the online automated question answering system incorporating Bloom taxonomy is shown in Figure 2. There are six main components in the system including learner assistant agent, lexical parser, domain identification, bloom taxonomy identification, forum discussion retrieval, and transformation module and response generator.

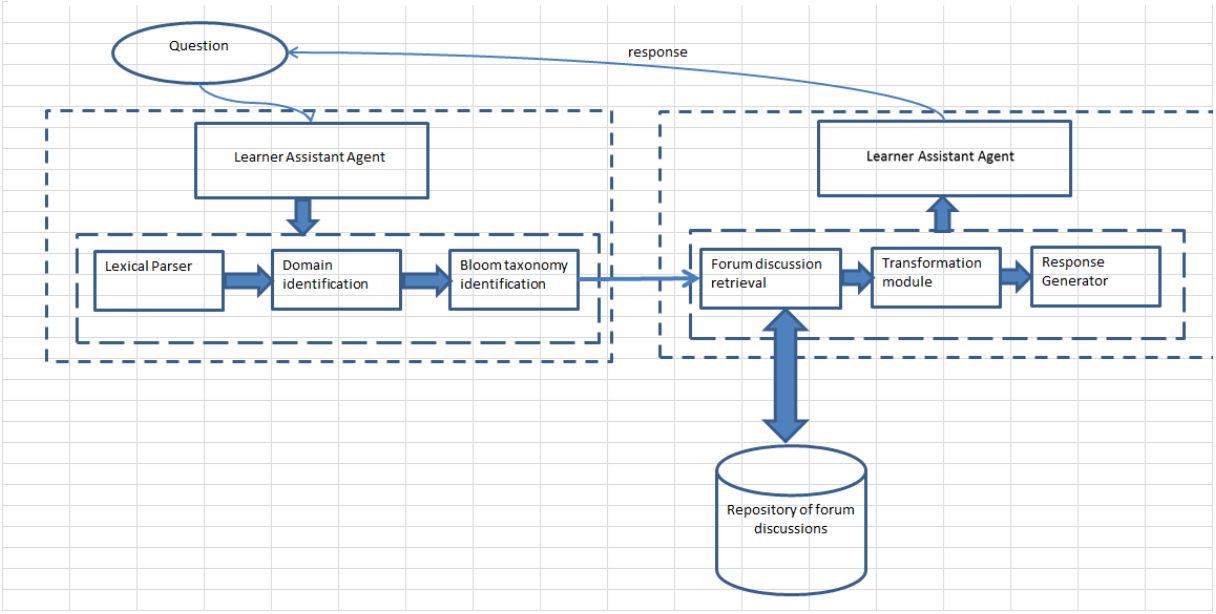

Figure 2:**Architecture of the Question Answering System**

Learner Assistant Agent: The main function of this component is to be the interface between the learner and the Q&A system. It provides learner an interface to send his questions and receive answers. Based on this agent, learner can also provide relevance feedback to the instructor asking for manually answering the question if all the answers returned by the system are not satisfied.

Lexical Parser: This component accepts sentences from user question and recognizes compound words and phrases, and tags part-of-speech (POS) to them. These words combined with their POS would be used by the subsequent modules for identification.

Domain Identification: This component is to identify the desired domain requested by learners in question. Domain ontology approach based on ACM classification would be possible to identify the domain. Besides that, the use of Natural Language Processing (NLP) would also come into play.

Bloom taxonomy identification: Once the domain has been identified, the appropriate level of category in Bloom taxonomy has to be identified in question posed by learners. Naive Bayesian Classifier approach might be used to accomplish the task. Obviously, it would be challenging to identify the desired level of Bloom taxonomy due to limited information in question.

Forum discussion retrieval: This component is used to retrieve past responses of forum discussion from database based on domain context identified from question posed by learners. Subsequent questions from learners for clarification on prior responses would not require further retrieval of knowledge from database provided the expected responses are from within the same domain context.

Transformation module: This component is aimed at transforming the relevant past responses in unstructured form to a suitable form represented using ontology approach for example in order to match with the desired Bloom taxonomy requested by learners. Appropriate representation of knowledge is required to observe how Bloom taxonomy manifest in the past forum discussions. Text mining or data mining approach might be used to enrich further the responses in accordance to Bloom taxonomy.

Responses generator: This component would package responses to learner assistant agent which would send responses to learners.

IV. Conclusion and Future Work

Apparently, this paper identifies the potential use of text mining, artificial intelligence, natural language processing and other relevant technologies to incorporate bloom taxonomy

element into question answering system in e-learning.

Future work would involve in drawing up a more comprehensive architecture of individual technologies as mentioned above so as to understand and identify the interaction of various types of technologies in the question answering system before it can be put into practice in the real world context.

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