# Learning by teaching SQL Queries to Teachable Agent Using Meta-cognitive techniques

Aarij Mahmood Hussaan
*Faculty of Engineering Sciences & technology*
*Iqra University*
Karachi, Pakistan
aarijhussaan@iqra.edu.pk

Farhan Muhammad Hassan
*Faculty of Engineering Sciences & technology*
*Iqra University*
Karachi, Pakistan

*Abstract*—**Teaching is always said to be twice learning, the traditional SQL Teaching, Intelligent Tutoring Systems (ITS) performs the task to teach individuals SQL Queries, where user is taught by ITS, by giving some examples, using some scenarios, but we have introduced, learning by teaching technique in this ITS system, where student becomes a teacher and ITS becomes a student. In our system, an Artificial Intelligence based teachable agent, named as Iqra is introduced which behaves like a student and want to learn from the one who is using ITS system. First Student Tutor is taught SQL Queries by ITS system, then Student Tutor teaches SQL Queries to Iqra (The teachable Agent). The Performance of Iqra, determines the learning of the Student. We have incorporated Learning by Teaching and Meta-Cognitive Techniques. Our approach brings the teaching of SQL queries to the next Level of cognitive science, as it lets the individual's capabilities to explore more by training and testing its own student. In this System student tutor and Teachable Agent performances are measured and on the bases of previous quiz result, next SQL query to teach is advised by ITS. In the end If Iqra get 100% marks it means student Tutor has learnt 100%.**

*Index Terms*—**SQL Tutor, Learning by Teaching, Teachable Agent, Meta-Cognition.**

## I. INTRODUCTION

Intelligent Tutoring system(ITS) is an Artificial Intelligence based technology or program. The aim of ITS program is to work intelligently by getting some instructions from inputter and produce some output or feedback accordingly to address the performance of student like his strength, weakness and some other attributes. ITS normally monitors a students decisions and actions in simulated environment or scenarios, then evaluate them, present feedback and gathers the students knowledge and skills and their ability to apply them when required. Based on complete historical knowledge Student Model is being constructed in ITS and keeps it updated as much as student performance increases or decreases. [1] In this research we are proposing an ITS system for teaching SQL queries to students. Mitrovic, Antonija et al., introduced SQL Tutor on the web [7] which teaches SQL Queries, which provides feedback and hints when user makes any mistake. In their system, ITS teaches SQL queries to the user who is first given description then by following the table schema student generates SQL query. Structured Query Language(SQL) is a programming language for a particular application domain, designed to manage the data which resides in Relational Database Management Systems(RDBMS). The Data in the (RDBMS) is structured mainly in Data tables and Data views which contains data, arranged in a structured manner, according to its data types and relations. To add, delete, alter and select required data, SQL queries are used. SQL queries are divided in to 3 main categories; 1. Data Definition Language (DDL), it is used when structured of database is required is be added, altered or deleted. 2. Data Manipulation Language(DML), it is used when actual data is Inserted, Deleted, Updated and Selection is required. 3. Data Control language (DCL), it is used when database is restricted to only specific users and Granting and Revoking their rights on specific database is required. [6]. In this research we have also included one of the newly explored study branch of ITS system named as "Learning by teaching" to teach SQL queries to a Teachable Agent which is described as follows; Teaching is said to be twice learning many studies proved that when a teacher teaches to student then teacher's learning become more substantial and improved, it is because when teacher wants to teach student, first he has to study that particular topic by himself then he teaches to his student. [2] Hence the process includes learning then keeping it updated and transferring that knowledge to student. These all processes like thinking, memorizing, learning, teaching, presenting, viewpoints, attention, reasoning, language and all other mind processes come in the criteria of cognitive science as cognitive science is an integrative study of mind and its processes which includes getting knowledge, processing it, transforming it and presenting it. The Cognitive science also relates with following subjects like psychology, philosophy, artificial intelligence, neuroscience and linguistics. [3] Getting the knowledge does not complete our learning, if student want

to sustain the knowledge, want to keep the knowledge for a longer time, want to learn faster, want to learn better than others, want to learn smartly, want to explore new things by his own, the answers for all above questions is to have some Meta-Cognitive strategies. It includes, like thinking about thinking or in simple words when someone in doing something to improve his cognition, that comes in the criteria of Meta-Cognition for example, if a student solves a mathematical equation then it is cognitive action but to improve his equation solving capability, if that student solves that equation again and again or solves similar equations for improving concepts, it is a meta-cognitive strategy. Another example, if a student starts learning a French language and during his learning, if he watches or listens French Videos or Audio help to improve his linguistic capability than it also comes in the Meta-Cognition because learning language is a cognitive action and for improvement, watching or listening or doing any other act to improve its cognitive ability that is a meta-cognition. [4]. The considerable positive effects of learning by teaching has now become the center point for every pedagogy expert. Researchers are now being more attracted towards this aspect of teaching and considering and prioritizing this aspect in new pedagogical design for better teaching. The design is so simple where, one student can be a teacher and can teach another student, after some self-learning. [5]. The rest of the paper is organized as follows: Section 2 presents the related work. Section 3, presents the overall design of our systems. Section 4 presents our conclusions and future research directions.

## II. RELATED WORK

In teaching SQL, an ITS system by Mitrovic, Antonija [8] which teaches SQL queries to students or users. It is web based and includes Student Model and others but specially includes Constraint Based Model(CBM), which defines rules and regulations. CBM shapes learning from Declarative Knowledge to Procedural Knowledge. When a user makes mistake their ITS system shows hints to user to help them make correct SQL query for given description. However, till now Learning by Teaching has not been applied on teaching SQL queries though it would rise the performance of user and their ability of learning more and complex description as teaching is twice learning. [2].

[12] In this paper 3 kinds of ITS systems are introduced: (a). ITS without Learning by teaching technique, a version where the students were taught by an agent (Mr. Davis). Mr. Davis, teaches, takes quiz, hints and gives grades and remarks after quiz. (b). Second Version, with learning by teaching technique but less feedback from Teachable agent, System a baseline learning by teaching version, where student is a teacher, who teaches and asks questions to Betty (A Teachable Agent) and she Answers the question asked. She also takes quiz and another agent Mr. Davis (another Agent) that gives grades and remarks on quiz results to student and Betty. (c). Third Version, with learning by teaching version, with feedback from teachable agent, System a Learning by teaching version where students received feedback on self-

regulated learning strategies and some domain content. Where Student is a teacher, Betty (A teachable Agent) being taught by student. She takes quizzes, Answers questions. The great thing in this version is after quiz, if the performance or result is not good then she requests her student teacher to learn more about the topic and go for review and then teach her and take quiz for better results. Also, once the quiz is taken and without teaching new lesson, if second quiz is asked to take then she replies that as she has not been taught new lesson, the results will be same and it would be better if student teacher teaches new lesson before taking next quiz. Initially Students should be taught on ITS and LBT, after that SRL, which will improve the meta-cognitive strategy of student.

Another ITS system by Salma Ahmed [9] In this paper, a web based ITS Model is discussed, based on Multi, layer and multi Models Architecture. Includes Quizzes, Student Profile. It is Platform and Hardware independent. Only Needs browser, applet and Internet. Student can learn any time any place 24/7. however dynamic quizzes from the user according to his strength and weakness is deficient. It may improve, if cognitive strategies as dynamic curriculum design is adopted and focusing on student strength and weakness in quizzes are considered for teaching next lesson or taking next quiz, in ITS system. It might also improve pedagogical model for better learning. [9]

In Learning by Teaching, Artificial Intelligent based, Teachable Agents are used, to act as a student who is willing to learn SQL queries, who has no knowledge about SQL query and want to learn from the user who is using SQL teaching ITS system. When we talk about exploring ideas and knowledge, in ITS Open-Ended Learning Environment is the key to exploration where Student tutor teaches Teachable Agent, by making diagram of knowledge tree and links its component for conception [10] In this Paper, and ITS with learning by teaching, Based on Open Ended Learning Environment, which uses component blocks and Links to make a conceptual map for making learning and reaching to its goal of understanding the topic or teaching. But this is limited to well English language proficient and mentally very strong minded people, less English proficient and less cognitive skilled people are not suited for this system. According to this paper student facing issues in finding appropriate resources for teaching TA, due to that poor teaching and poor student performance.

[11] In this paper, An ITS, based on Learning by Teaching is discussed. First student learns from Learning Resource Tab and then start teaching the Teachable Agent (TA), Betty, in Open Ended Learning Environment (OELE). In this research student learning behavior, actions, feedback and performance are measured by TOP Down and Bottom Up Approaches. Top Down Approach Focuses on the Student Feedback and Achievements of learning Goals. Bottom Up Approach focuses on student action, performance and logs that monitors frequent actions for any event.

[13] In this paper, the Learning Material on the Internet in the form of text, Graphics, Videos, Audio etc. or mainly called hypermedia is available in structured or unstructured

manner. The students and teachers, all can get benefits from it. But only availability is not the answer to the question, the appropriate material on appropriate time and by appropriate way to everyone from any place by using internet is the solution for better learning and teaching. According to this research, ITS should be, Easy to use, flexible and scalable. One ITS system should contain multiple ITS systems that can be, removed, modified or added anytime according to requirement. Multiple ITS could be included for teaching particular topic

[14] According to this paper, students get misconceptions when they are studying in their domains, to identify the misconceptions, teachers have to make strategies to improve student learning. In identifying the misconceptions and remedial actions, Intelligent Tutoring Systems can play a Vitol role. In this research, by Data Driven techniques using an ITS system that teaches Conceptual Database Design, named as EER-Tutor (Enhanced Entity Relationship data modeling) tutor, which is a Constraint Based ITS. By using Student Model, which contains complete history, actions, performance, weaknesses, strengths and data of misconceptions, which is more than 1000 students data. Which based on ¡Cr, Cs¿, Cr = Constraint Relevance and Cs =Constraint Satisfaction. First Cr is checked then Cs, if both are satisfying able then it will be considered as Right Concept otherwise. Misconception. As a future work, they want to add tagging the Misconception because of Huge data and still data differentiating is a big issue.

[15] This paper introduces KERMIT, Knowledge based Entity Relationship Modeling Intelligent Tutor. It is Used and tested on University Students for Designing and Practicing Conceptual Database Design, using Entity Relationship Data Model and it is based in CBM, Constraint Based Model for making Student Model and Knowledge Model. (a). User Interface: Problem is presented by system =¿ Student Interacts with User InterfaceMain Component is User Interface from where student, draw Entity Relationship Model or schemas. (b). Pedagogical Model: It is the Model that drives the whole system, according to every Student Selects Instructions from System => Selects the problems suited to every individual student. (c). Student Model: Student Module is based on CBM, which assess student's solution with system knowledge and student knowledge in student Model.

[16] In this paper, An Intelligent Tutoring System, that teaches, Relational Database Normalization Schemas, named as A Normalization Tutor(ANT). Based on Weighted Total Misconception which decides whether to increase the level or decrease. If Misconceptions are higher than student will be demoted to previous level. If Misconceptions are lower, then student will be promoted to higher level.

[17] The effect of learning by teaching has been well known in many disciplines for diverse student populations and skill levels. Many empirical studies observe that when students tutor each other, not only tutees but also tutors learnoften called the tutor-learning effect. As Teaching is twice learning, because whenever we teach someone we learn better than before. The Software program or the environment is used is an online learning system called APLU. In which a Teachable Agent called SimStudent (named as Mandy) Which is being tutored by students and another AI agent called Mr. William, which acts as a meta-cognitive help that monitors the performance of not only the student who is teaching the teachable agent but also the performance of Teachable Agent. Their data also suggested that, the careful design of tutoring system and the Meta-Cognitive techniques can be a great scaffolding or help for not only in terms of learning by teaching for effective tutoring of Teachable Agent that includes both how to teach (meta-cognitive help) and what to teach (cognitive help) and also improves cognitive skills of individual.

## III. DESIGN

### A. Student Model

In our system, student is referred to as Student Tutor (ST), the one who is willing to learn SQL Queries. In order to do so, s/he has to follow a Learning by Teaching approach. The student teaches a Teachable Agent (TA). The TA will then be assigned to solve some tasks relating to SQL queries. The better the student teaches the TA the better will be TAs performance on SQL tasks. However, in order to teach the TA, the student must first learn by him/herself. The performance of TA will judge the learning of Student Tutor (ST). The Student Model comprises of the General user information like, Name, Age, Study Background, Previous SQL experience. Learning Info: Self Study: Topics Self Studied, Topics Self Study Remaining, Current Self Study Topic. Strength, Weakness. And, Teaching to TA topics by Student Tutor: Topics Taught, Topics Remaining, Topic Currently teaching.

### B. Domain Model

In Domain Model, topics to be covered during training and testing and its flows from starting to End are discussed. In Teaching and Learning SQL queries, Domain model incorporates following topics and its flow in figure 1. In this work, we will be primarily focusing on Data Modification queries. In particular, our focus is on Select, Insert, Update, and Delete queries. For select queries, we have queries that return all columns, or selected columns. For each type of select query we have queries that require to return results in a particular order, meeting particular conditions, and/or return duplicate or distinct values. For insert queries, our system teaches both queries with column names and without column names. For update/delete queries, we teach queries that updates/deletes records from the database. Some sample queries that were present in our system.

**Select**
SELECT column_name,column_name
FROM table_name;
SELECT * FROM table_name;
**Select - Distinct**
SELECT DISTINCT column_name,column_name
FROM table_name;
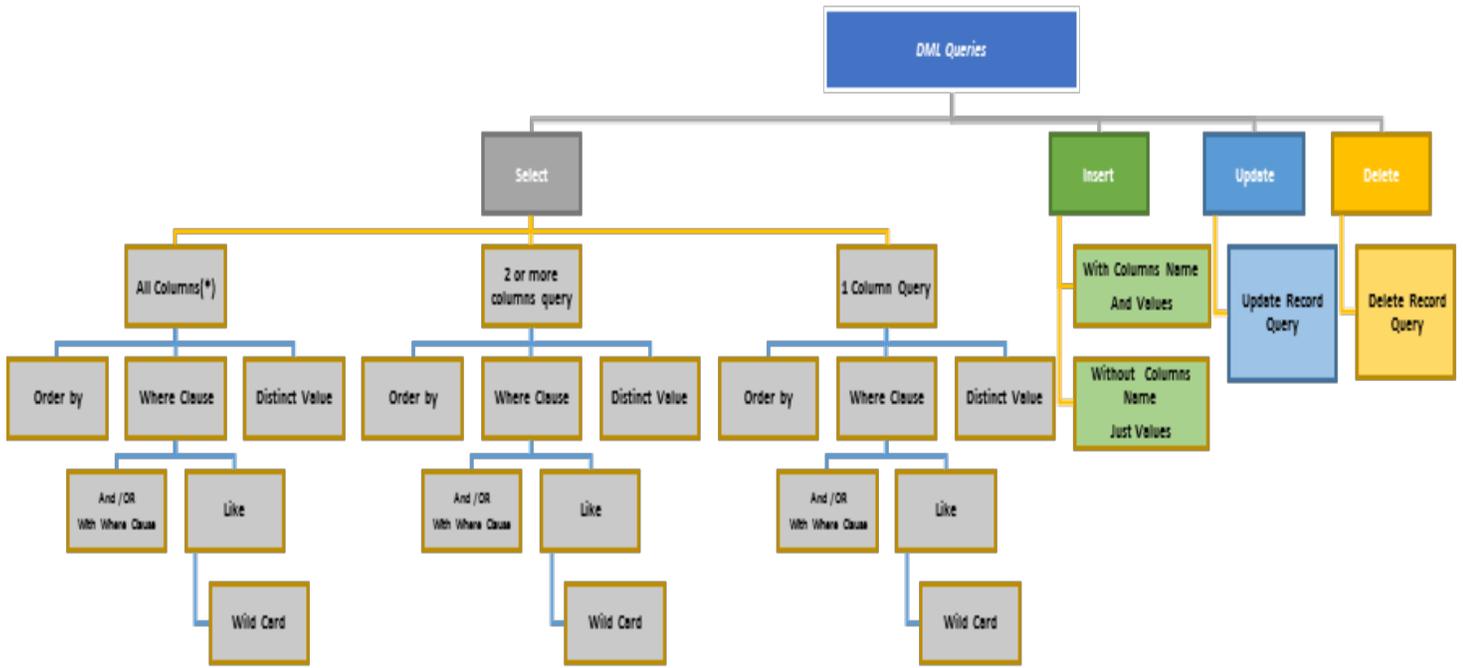
**Select - Order**
SELECT column_name, column_name
FROM table_name
ORDER BY column_name ASC—DESC, column_name
ASC—DESC;
**Select Where Clause**
SELECT column_name,column_name
FROM table_name
WHERE column_name operator value;
**Select Where AND - OR**
SELECT * FROM Customers WHERE Country='Pakistan'
AND (City='Karachi' OR City='Lahore');

TABLE I
KNOWLEDGE MODEL

| Word | Description | Table Name |
|---|---|---|
| Employee | Table | |
| EmployeeId | Attribute | Employee |
| FirstName | Attribute | Employee |
| LastName | Attribute | Employee |

TABLE II
SQL QUERY ORDER

| Elements | Element Order | Number of Elements | Key Words |
|---|---|---|---|
| SelectionAttribute1 Aggregate Function Count Aggregate Function Attribute Aggregate Function | Select SelectionAttribute1 Aggregate Function Count Aggregate Function Value | 18 | Having Group by Inner Join Count Select |

### C. Teachable Agent Model

The teachable agent (Iqra) is the crux of our system. Here we describe the working of our agent. Iqra has two modes, namely 1) Training, and 2) Testing. In the training mode, the student teaches Iqra with different sql query concepts. In the testing mode, Iqra takes an exam given by our system. If the result of the test is not satisfactory then the student has to retrain Iqra. In order to do so the student has to retrain himself/herself. The whole process of learning via teaching is as follows: - Teachable Agent Learns during training and save marked knowledge words, type and description, as shown in Table 1. - During Training, Iqra also stores SQL Query, Key elements its numbers and its order, as shown in Table 2. - At the time of Test, Teachable Agent gathers all its knowledge and finds the best possible knowledge to answer the SQL Query asked by User via User Generated Description in Testing.

### D. Training

Description => Mark Symbols (Create Symbols, if required) => check spell of table and attribute => Set SQL Query Order and add commas and Brackets where necessary. => Set keywords=>
(Save SQL Query Order with description Knowledge)



For example, the description generated by the systems is

like
Get Employees LastName , count Orders orderid as NumberOfOrders from orders Inner Join with employees on Orders Employeeid with Employees EmployeeId group them by Employees lastname only those Orders OrderID which are greater than 10;
The symbol based description will be like:


$Get$ = Select
_sa1_Employees LastName_sa1_ = Employees.LastName
_AFCount_ count _AFCount_= Count
_AFA_Orders orderid_AFA_ = Orders.Orderid
_AFAlias_ as NumberOfOrders_Alias_= as NumberOfOrders
!From! = From
_#1_Orders_#1_= Orders
_X_Inner Join_X_= Inner Join
_#2_Employees_#2_= Employees
_On_ON_On_= On
_IJsa1_ Orders Employeeid _IJsa1_= Orders.EmployeeId
_IJsa2_ Employees EmployeeId _IJsa2_= Employees.EmployeeId
_gb_ group them by _gb_ = Group by
_gbsa_ Employees lastname_gbsa_= Employees.Lastname
_having_only Those_having_= having
_havingSA_ Orders OrderID_havingSA_= Orders.Orderid
_Gt_Greater Than_Gt_= >
_havingSAV_10_havingSAV_ = 10


The description after making and adding symbols
$Get$ _sa1_Employees LastName_sa1_ _AFCount_ count Orders orderid _AFCount _AFAlias_ as NumberOfOrders_Alias_!From! #Orders#_X_Inner Join_X_ #Employees#_jk_ON_jk_
_jsa1_ Orders Employeeid _jsa1__jsa2_ Employees EmployeeId _jsa2_ _gb_ group them by _gb_ _gbsa_ Employees lastname_gbsa_ _having_only Those_having__havingSA_ Orders OrderID_havingSA_ _Gt_Greater Than_Gt_ _havingSAV_10_havingSAV_


After that the ITS will 1) Starts analyzing description. 2) Finding Errors (Syntax Mistakes, Keywords, Name of table or attribute). 3) Provides feedback, if it finds any mistake regarding setting symbols. Afterwards, the system will, 1) Start analyzing Query order, 2) Prompts hints or feedback, if it finds any Query order mistakes, 3) If finds No Error then Generates SQL Query.


SELECT
Employees.LastName,
COUNT(Orders.OrderID) AS NumberOfOrders
FROM
(Orders INNER JOIN Employees

ON
Orders.EmployeeID=Employees.EmployeeID)
GROUP BY LastName
HAVING COUNT(Orders.OrderID) > 10;

*E. Testing*

Testing will take place as follows: 1) Student Tutor will be provided Table Schema, 2) By Considering schema, student tutor or User will write a description in Description textbox, 3) TA will read description, check each word in its Knowledge table, if word found it will check its category and its position in SQL Query, 4) TA will Set SQL Query Order and add commas and Brackets where necessary and Generates SQL Query. 5) Set keywords, 6) (TA Save SQL Query Order with description Knowledge). The flow of this process is given below:
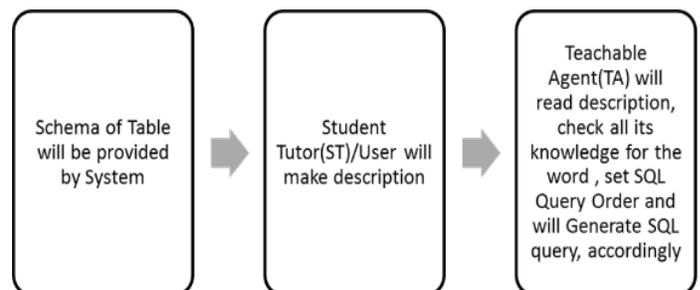


## IV. CONCLUSION AND FUTURE WORKS

On the light of the referenced research Learning by Teaching has proven to be the twice learning. For those who strives for better learning and good concepts and to improve cognitive strategies. There are people who want to learn when they want to learn, anywhere any time, Intelligent Tutoring system is the answer for all those questions. Our proposed system provides Intelligent Tutoring System with Learning by Teaching facility, to make your understanding far better than traditional Intelligent Tutoring systems. It does not only improve your cognitive and meta-cognitive strategies of learning but also provides you improved pedagogical model for learning SQL Queries and ability of exploring knowledge. From self-exploring learning to teaching a teachable agent gives a student well again understanding of SQL queries and its concepts that improve learning more and enhanced. For Future work, animated teachable agent could help student to keep them more attractive to ITS system for longer time.

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