QueryPRIMM: A PRIMM-Based Tool for Learning SQL

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Abstract

Students often find learning Structured Query Language (SQL) challenging, particularly when understanding how queries operate on relational data. Active engagement with queries and their results can help students build stronger understanding of SQL concepts. The PRIMM (Predict-Run-Investigate-Modify-Make) framework provides a structured approach for engaging learners with code through prediction, exploration, and modification activities.

This paper presents a web application designed to support learning SQL through PRIMM-based exercises. The platform guides students through predicting query outputs, executing SQL queries, investigating results, modifying queries, and creating their own queries within an interactive environment. The tool provides instructors with a structured way to incorporate PRIMM activities into SQL teaching, while allowing students to experiment with queries and observe their effects on relational data. The platform also supports the creation of custom PRIMM exercises that expand the available practice problems and allow customisation to specific course topics. We describe the system and present example questions that illustrate how it can be used to support SQL learning.

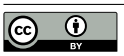
CCS Concepts

• **Social and professional topics** → **Computing education**; • **Information systems** → **Data management systems**.

Keywords

data systems, databases, SQL, PRIMM

ACM Reference Format:
Abdulhafith Ahmed, Martin Goodfellow, Lee Clift, and Damien Anderson. 2026. QueryPRIMM: A PRIMM-Based Tool for Learning SQL. In *Proceedings of the 31st ACM Conference on Innovation and Technology in Computer Science Education V. 2 (ITiCSE 2026), July 10–15, 2026, Madrid, Spain.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3803401.3811960



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ITiCSE 2026, Madrid, Spain
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ACM ISBN 979-8-4007-2633-0/2026/07
https://doi.org/10.1145/3803401.3811960

1 Introduction

SQL is a core component of many computing curricula [3] and is the standard language for interacting with relational databases. However, students often find it challenging to understand how queries operate on relational data and how changes to a query affect the resulting output. Developing this understanding typically requires students to experiment with queries, observe their effects, and reason about how database operations behave. Providing structured opportunities for this kind of exploration can be difficult within traditional teaching activities.

One pedagogical approach designed to support programming learning is PRIMM (Predict-Run-Investigate-Modify-Make), which structures learning activities around progressively deeper engagement with code [4]. The approach encourages students to first predict the behaviour of a program, run it to observe the outcome, investigate how it works, modify existing code, and finally create their own solutions. This scaffolded progression helps learners build confidence and understanding by working with existing code before developing their own programs [5, 6]. PRIMM has been successfully applied in a range of programming education contexts and has been shown to provide educators with a clear structure for designing programming activities [1, 2].

Despite its benefits, applying PRIMM activities to SQL learning can be challenging in practice. In particular, creating structured exercises that allow students to predict, run, and explore the behaviour of database queries requires appropriate tooling and interactive environments.

This paper presents a web application designed to support the learning of SQL using the PRIMM framework. The system provides an interactive environment in which students can engage with SQL queries through prediction, execution, investigation, modification, and creation tasks. The tool supports instructors in incorporating PRIMM-style activities into database teaching, while allowing students to explore how SQL queries interact with relational data.

2 QueryPRIMM

We have developed QueryPRIMM, a web application that supports SQL learning through structured PRIMM exercises. The platform is implemented using Django and SQLite and includes three built-in question sets covering fundamental SQL concepts. These are, `SELECT` and `WHERE` operations, aggregate functions, and `JOIN` operations across multiple tables.

Table 1: The database schema. Underlined attributes are the primary key for each table.

Table name	Attributes
employee	first_name, last_name, email, phone, job_title, department, salary
project	project_name, start_date, end_date, city, employee_email

The platform supports interactive query execution against a pre-populated database with results displayed in formatted tables and hints generated for incorrect answers. The database is visualised showing the schema and data for student reference. Additionally, instructors can create custom PRIMM question sets to explore other SQL concepts and learning objectives. The platform is publicly available on GitHub [1] and can also be accessed online [2].

2.1 Example

To illustrate how QueryPRIMM structures SQL learning activities, the following details an example from the JOIN operations question set, using a database with employee and project tables. The schema is shown in Table 1.

Predict and Run. The students first predict the behavior of a query via a multiple choice question. They select from four options; and press the RUN button to execute the query. They then see the actual results in a formatted table, allowing them to compare their prediction with the query output. The multiple choice question is shown below, with the correct answer shown in bold.

Q: What do you think will happen when the following SQL query is run?

```
SELECT e.first_name, e.last_name, p.project_name
FROM employee e
INNER JOIN project p ON e.email = p.employee_email;
```

(a) It will return all employees, even those without projects.
(b) It will return only employees who have projects.
(c) It will return all projects, even those without employees.
(d) It will return an error.

Investigate. Students then answer three targeted questions about specific query components. For example, what happens to employees who do NOT have any projects assigned when using INNER JOIN?

After submitting, students see their answers alongside the correct ones and are encouraged to reflect on and investigate the differences.

Modify. Students are then asked to modify the original query to show only projects that started after January 1, 2023. The system executes the modified query, displays results in a table, and indicates whether the output matches the expected results.

[1] https://github.com/Mebruh/PRIMM-Tool
[2] https://sqlprimmtool.pythonanywhere.com/

Make. Finally, students write a complete SQL query from scratch to list all employees who do NOT have a project.

Incorrect queries receive keyword-based hints without revealing complete solutions. Upon completion, students are congratulated for completing the question set and directed to the next question set.

3 Conclusion

We presented our web-based tool for supporting SQL learning through PRIMM-based exercises. The platform allows students to predict, run, investigate, modify, and create SQL queries within an interactive environment, supporting active engagement with relational data. It provides instructors with a structured way to incorporate PRIMM activities into their teaching and offers students opportunities to explore queries and observe their effects. By enabling hands-on experimentation and reflection, the tool is designed to support deeper engagement with SQL and a stronger understanding of relational queries in both introductory and advanced database courses.

Several enhancements could extend QueryPRIMM's capabilities. The Investigate stage could incorporate conversational AI to allow students to discuss their answers interactively and receive personalised support. Additionally, supporting dynamic database creation through an administrative interface would enable instructors to upload schemas and populate tables without editing the source code. Finally, learning analytics could be added to track student progress and help identify areas of difficulty.

Acknowledgments

The web application originally started as a group project for the University of Glasgow's CSETP course under the supervision of Maria Kallia, and Quintin Cutts. Other members of the project were: Kevin Cahil, Saad Baig, Mateusz Kloska, and Raaed Sattar.

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