

# Design and Implementation of Web-based Database Virtual Experiment Platform

Yun Liu and Dong Xiao

Information Center, Hainan Vocational College of Political Science and Law, Haikou Hainan, 571100, China

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**Abstract:** Against the backdrop of the COVID-19 pandemic, many courses face challenges in online teaching. Enhancing the teaching quality of online experimental sections in current higher vocational database courses is an urgent need. This paper constructs a lightweight web-based database virtual experiment platform. The results show that the platform can effectively solve the problems of difficult implementation and uncertain experimental effects in experimental sections under the blended learning mode of database courses, effectively ensuring the quality of online teaching for such courses.

**Keywords:** Hybrid Teaching; Database Teaching; Virtual Experiment.

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## 1. Introduction

Due to the impact of the COVID-19 pandemic, large-scale online teaching has become a "new normal" in the teaching mode of higher vocational colleges, showing a trend of "all subjects, all courses." Meanwhile, in recent years, the rapid development of Internet technology has led to an explosive growth in blended learning. Blended learning has become one of the main teaching modes for online teaching, and innovation in talent cultivation and teaching reform in higher vocational education are calling for blended learning. Higher vocational education emphasizes "learning by doing and doing by learning," integrating practical training into the blended learning mode, which can greatly enhance the effectiveness of blended learning. However, the teaching of database courses in higher vocational education has high requirements for experimental environments. Traditional experimental methods, software platforms, and terminal devices are unable to meet the needs of the blended learning mode. Constructing a lightweight browser-based database virtual experiment platform can effectively solve the problems faced by traditional classroom experimental teaching, allowing students to practice SQL language without being restricted by experimental venues and time, and enabling them to use low-configured terminal devices such as mobile phones and tablets even without internet access.

In recent years, Internet-based remote experiments have attracted increasing attention. Many well-known universities in China have established their own remote experiment platforms and conducted experiments in courses such as physics, chemical engineering, mechanical engineering, and electrical engineering. For instance, Feng Wei et al. [1] designed a laboratory remote data monitoring system to monitor, control, and centrally manage the underlying three-capacity water tank experimental platform, providing real-time and reliable data to remote clients. Chen Jianfei et al. [2] used embedded technology, network communication technology, Web application technology, and education identity-based real-name authentication technology to design and develop a remote experiment control platform, realizing online reservation, remote control, intelligent management of remote laboratory experiment projects, as well as fault detection of remote experiment equipment and user access security control. However, there is limited research on virtual

training platforms for database courses. A search in the CNKI database using keywords such as "database + training platform," "SQL + training platform," "database + experiment platform," and "SQL + experiment platform" yielded few relevant research papers. These studies mainly fall into three categories: the first category starts with the reform of the teaching mode of the course, using blended teaching mode to "enhance students' practical innovation ability and improve the teaching quality of the course," but these studies do not delve into how the involved experimental platforms are constructed or how online and offline training sessions are implemented. The second and third categories mainly focus on constructing online experimental systems based on the B/S architecture. The difference lies in that the second category of experimental systems mainly focuses on analyzing the syntax of SQL statements entered by students and judging whether they are correct or not, without focusing on returning the execution result set to students [3]; the third category of systems has richer functionality. Students can not only use browsers to access learning resources published by the system but also conduct online SQL statement experiments on the system and view execution results [6][8][9]. However, due to different technological approaches, some systems can only simulate partial SQL operations and cannot fully cover database language knowledge points. Some systems also have conflicts when users operate data on the browser side, affecting the experimental results.

## 2. Platform Design

### 2.1. Technical Solution Selection

Under the blended learning mode, students have various types of access devices. To avoid affecting the normal conduct of teaching activities due to reasons such as device hardware configuration and the quality of the learning environment network, the system should be as friendly to devices as possible, with lightweight and user-friendly functionality, and it should also be able to function normally in offline environments. Based on these requirements, this platform adopts AlaSQL as the system database. AlaSQL is a lightweight database based on client browser memory. Since it is written in pure JavaScript, AlaSQL is suitable for the vast majority of browsers nowadays. Additionally, AlaSQL has comprehensive functionality, supporting data operations such

as SELECT, VIEW, JOIN, GROUP BY, IN, UNION, ALL, ANY, CUBE(), ROLLUP(), subqueries, etc., which basically cover all the knowledge points of database practical training in higher vocational education.

## 2.2. System Architecture Design

Considering the diversity of student training devices and the network environment, the system should be lightweight and able to function normally in various network environments. Therefore, this system mainly consists of frontend components, allowing offline devices to directly run and use on local machines. Additionally, the system is

configured with a web server for devices connected to the internet to access directly. Before class, teachers can import prepared teaching simulation data into the system, which supports importing various data formats such as csv, txt, json, etc. Students can access the system in two ways: for students who may not have a network or have poor network quality during operation, they can download the system program files to their local machines in advance and directly execute the html-formatted program files for training; for students with better network quality, they can directly train online using their device browsers at any time. The operation process of the system is shown in Figure 1 below.

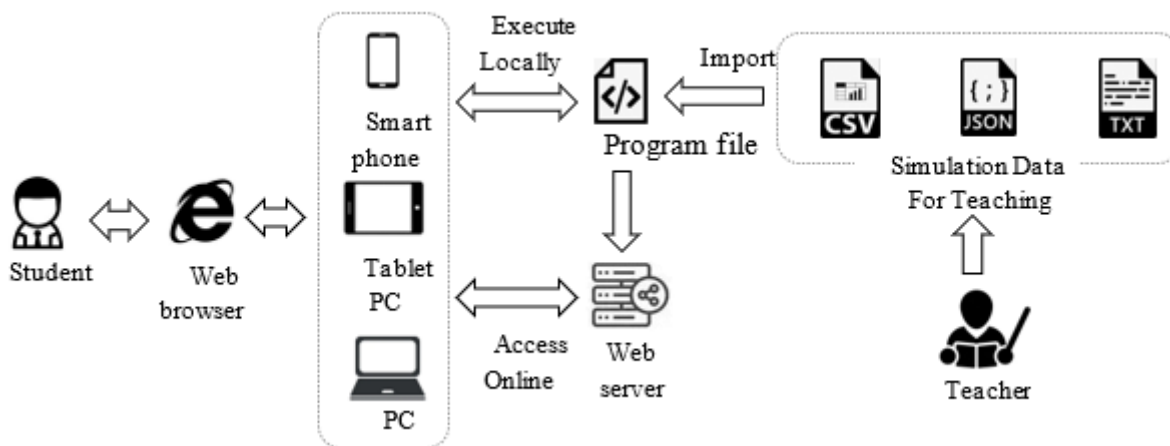


Figure 1. Illustration of System Operation Process

## 3. System Interface and Key Feature Implementation

### 3.1. Main Interface of the System

The virtual experiment platform adopts the Bootstrap frontend development framework, while related database simulation operations are implemented using JavaScript to call AlaSQL functions. The main interface is divided into three parts: the navigation area, the demonstration area, and the training area. The fixed selection list on the left serves as

the navigation area, listing basic queries, conditional queries, projection queries, multi-table queries, data insertion, data update, data deletion, and other training tasks. The upper right part displays the demonstration data used for this training task, including table structure, partial records, syntax introduction, and operation tips. The lower right part, in black, is the training area where students can input relevant SQL statements into the input box and click the "Execute SQL" button to observe the execution results below. The interface is illustrated in Figure 2 below.

✿ Virtual Experiment Platform for SQL

Basic Knowledge

1. SQL SELECT
2. DISTINCT
3. WHERE
4. AND operator
5. OR operator
6. NOT operator
7. ORDER BY
8. TOP
9. MIN() and MAX()
10. COUNT ()
11. AVG ()
12. SUM ()
13. IN operator

> Demo Data

> Simulation

### Demo Data

Here is the example database's structure and partial content of the 'students' table:

sno	name	sclass	sex	age	nation	address
21040501	Deng	0405	female	19	han	Hainan
21040502	Fu	0405	male	21	li	Hainan
21040503	Fan	0405	male	19	han	Zhejiang
21040643	Zhu	0406	male	22	han	Hainan

### Simulation

-- Querying the first five entries of the scores table

SELECT TOP 5 \* FROM scores

NOTE: 1. You can modify the SQL statement in the input box above.  
2. Click the button below to view the SQL execution result.

Execute SQL

Figure 2. Main Interface of the Platform

## 3.2. Implementation of Key Features

### 3.2.1. Importing Demonstration Data

The demonstration data for each training task page needs to be written into the code file in advance. When students access the page, the browser will load this data into local memory. Students' operations on the data are all local, and there will be no conflicts with the operations of other students. If students make mistakes, they can refresh the page to restore the demonstration data for this task to its initial state. The following is a part of the JavaScript code for constructing demonstration data:

```
alasql("CREATE TABLE students (sno STRING,name
STRING, sclass STRING, sex STRING, age INT, nation
STRING, address STRING)");
```

```
alasql("INSERT INTO students VALUES ('21040501',
'Deng', '0405', 'female', 19, 'han', 'Hainan')");
```

```
alasql("INSERT INTO students VALUES ('21040502', 'Fu',
'0405', 'male', 21, 'li', 'Hainan')");
```

```
alasql("INSERT INTO students VALUES ('21040503',
'Fan', '0405', 'male', 19, 'han', 'Zhejiang')");
```

The above code automatically creates the 'students' demonstration data table and its structure when the page is loaded, and inserts several simulated records into the table.

### 3.2.2. Execution of Training SQL Statements and Result Display

After students input relevant SQL statements into the input box and click the "Execute SQL" button, the runSQL() function is executed. This function extracts the text input by the student and passes it as a parameter to the alasql() function to execute relevant data operations. Then, the result set in JSON format is passed to the appendTable() function for HTML formatting. Finally, the formatted result is appended to the relevant DOM of the user page, allowing students to visually see the table-formatted result set in the "Execution Results" area. Additionally, errors are caught using try...catch... and error messages are presented to the user in the form of warning windows. Below is a part of the JavaScript code for formatting the result set returned by the

alasql data operation:

```
function appendTable(json) {
    parseHead(json[0]);
    var div = document.getElementById("myconsole");
    div.innerHTML = "";
    var table = document.createElement("table");
    table.classList.add("table");
    table.classList.add("table-dark");
    var thead = document.createElement("tr");
    for (var count = 0; count < headArray.length; count++) {
        var td = document.createElement("th");
        td.innerHTML = headArray[count];
        thead.appendChild(td);
    }
    table.appendChild(thead);
    for (var tableRowNo = 0; tableRowNo <
    json.length; tableRowNo++) {
        var tr = document.createElement("tr");
        for (var headCount = 0; headCount <
        headArray.length; headCount++) {
            var cell =
            document.createElement("td");
            cell.innerHTML
            =
            json[tableRowNo][headArray[headCount]];
            tr.appendChild(cell);
        }
        table.appendChild(tr);
    }
    div.appendChild(table);
}
```

The interface for SQL training and the execution result is shown below in Figure 3.

Virtual Experiment Platform for SQL

Basic Knowledge

1. SQL SELECT
2. DISTINCT
3. WHERE
4. AND operator
5. OR operator
6. NOT operator
7. ORDER BY
8. TOP
9. MIN() and MAX()
10. COUNT ()
11. AVG ()
12. SUM ()
13. IN operator

Demo Data

Simulation

Simulation

-- Querying the first five entries of the scores table

```
SELECT * FROM scores where sno in
(select sno from students
where sex='male' and nation<>'han')
```

提示: 1. You can modify the SQL statement in the input box above.  
2. Click the button below to view the SQL execution result.

Execute SQL

Result

sno	name	cid	s1	s2	s3	sclass
21040502	Fu	33269	76	79	78	0405
21040514	Zhu	33269	76	79	78	0405
21040521	Liu	33269	78	78	78	0405
21040619	Li	33269	85	90	88	0406
21040631	Mo	33269	65	88	79	0406

Figure 3. SQL Training and Execution Result Interface

## 4. Analysis of Virtual Experiment Platform Usage

After the main functions of the platform were implemented, practical usage was carried out in the "Database Technology and Applications" course taught by the author. As the course was conducted during a period of recurrent COVID-19 outbreaks in the region, a blended teaching mode with online teaching as the main approach was adopted. Before the course began, an electronic questionnaire was distributed to 66 students participating in the course to understand their experimental equipment and environment. The survey results showed that 66.7% of the students had personal computers for practicing at home, while 33.3% could only use smartphones to participate in course teaching activities. All students had

stable network environments at home, enabling them to access the system online for training at any time.

By the time this article was written, 28 online experimental tasks had been released. According to the design of the blended teaching mode, all these tasks were interspersed throughout relevant online classroom teaching activities. Students were also required to upload screenshots of their practice results on the virtual experiment platform after completing each experimental session. According to statistics from the learning platform's backend data, all students were able to carry out SQL training online normally. With the exception of a few students with weaker foundations, the vast majority of students were able to complete the online training tasks as scheduled. Specific completion statistics are shown in Figure 4 below.

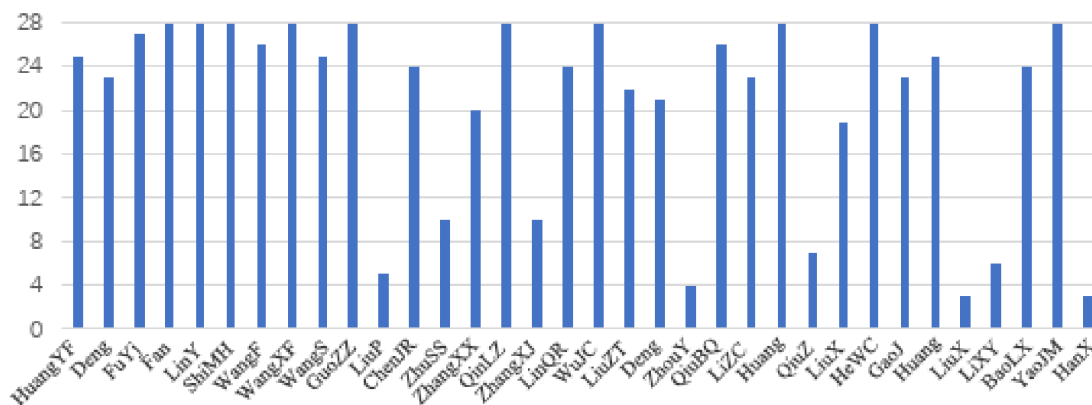


Figure 4. Completion Status of Online Experimental Tasks

## 5. Conclusion

Based on the analysis of the blended teaching requirements for database courses in higher vocational colleges, this paper proposes a virtual experiment platform based on AlaSQL. The overall implementation approach of the system is analyzed, the system architecture is designed, and the system is implemented using the Bootstrap development framework. Since its deployment, the system has performed well overall, and students can smoothly use the platform on various types of terminal devices. The platform provides the possibility for adopting a blended teaching mode for courses of this type and effectively ensures the quality of online teaching for practical database courses in the context of the COVID-19 pandemic.

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