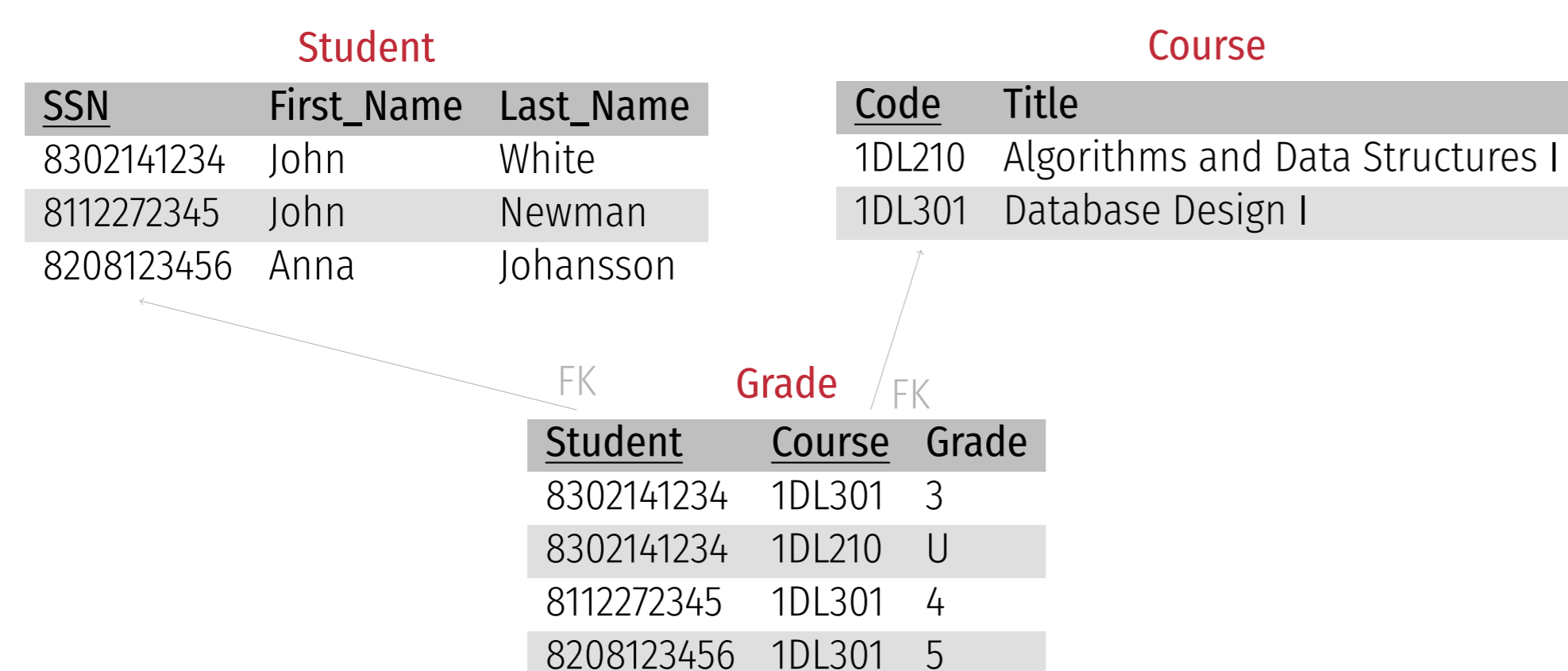


MOTIVATION

SQL—Structured Query Language—is the most used language for managing data stored in relational databases. To master this language is highly relevant for any student that will use this type of databases. Although the language is relatively simple, students usually experience some difficulty learning how to write complex queries. With a larger number of students, teaching SQL effectively becomes a challenging task.

RELATIONAL DATABASES AND SQL

Relational databases store data in one or more tables (*relations*), for example:



SQL is the most used language for creating, manipulating and querying data in relational databases. Example of an SQL query (returning the grades of all students that have taken the exam in 1DL301):

```
SELECT Student.First_Name, Student.Last_Name, Grade.Grade
FROM Grade, Student
WHERE Grade.Student=Student.SSN AND Grade.Course='1DL301'
ORDER BY Last_Name, First_Name
```

First_Name	Last_Name	Grade
Anna	Johansson	5
John	Newman	4
John	White	3

1DL301 DATABASE DESIGN I

- Undergraduate course
- 5 credits (hp)
- Introducing the basics of how to design, create, modify and query relational databases
- Given twice each academic year (in the first and the second period)
- 206 registered students in the second period of Fall 2018, mostly from the following programs:
 - Master Program in Computer and Information Engineering (IT)
 - Master Program in Molecular Biotechnology Engineering (X)
 - Master Program in Sociotechnical Systems Engineering (STS)
 - Master Program in Bioinformatics
- Students' prior knowledge, skills (including programming skills) and competence vary a lot between the programs

SQL is one of the most difficult parts of the course for students, esp. complex queries involving joining multiple tables, grouping of data, and nested queries.

Classes related to SQL

- **3 tutorial sessions** (à 2 hrs) in auditoria (the aula in ITC 6 and the Siegbahnsalen in Ångström)
 - The content is divided into several parts, starting with simple queries and moving towards more and more complex ones. Each part is briefly explained (incl. example queries) first. Students then practice SQL by solving a set of tasks with the help of the main teacher and two-three assistants.
- **Labs** (à 4 hrs) in computer lab rooms (at ITC and Ångström)
 - 1 lab dedicated to practicing SQL queries
 - 2 labs where students apply acquired knowledge and skills

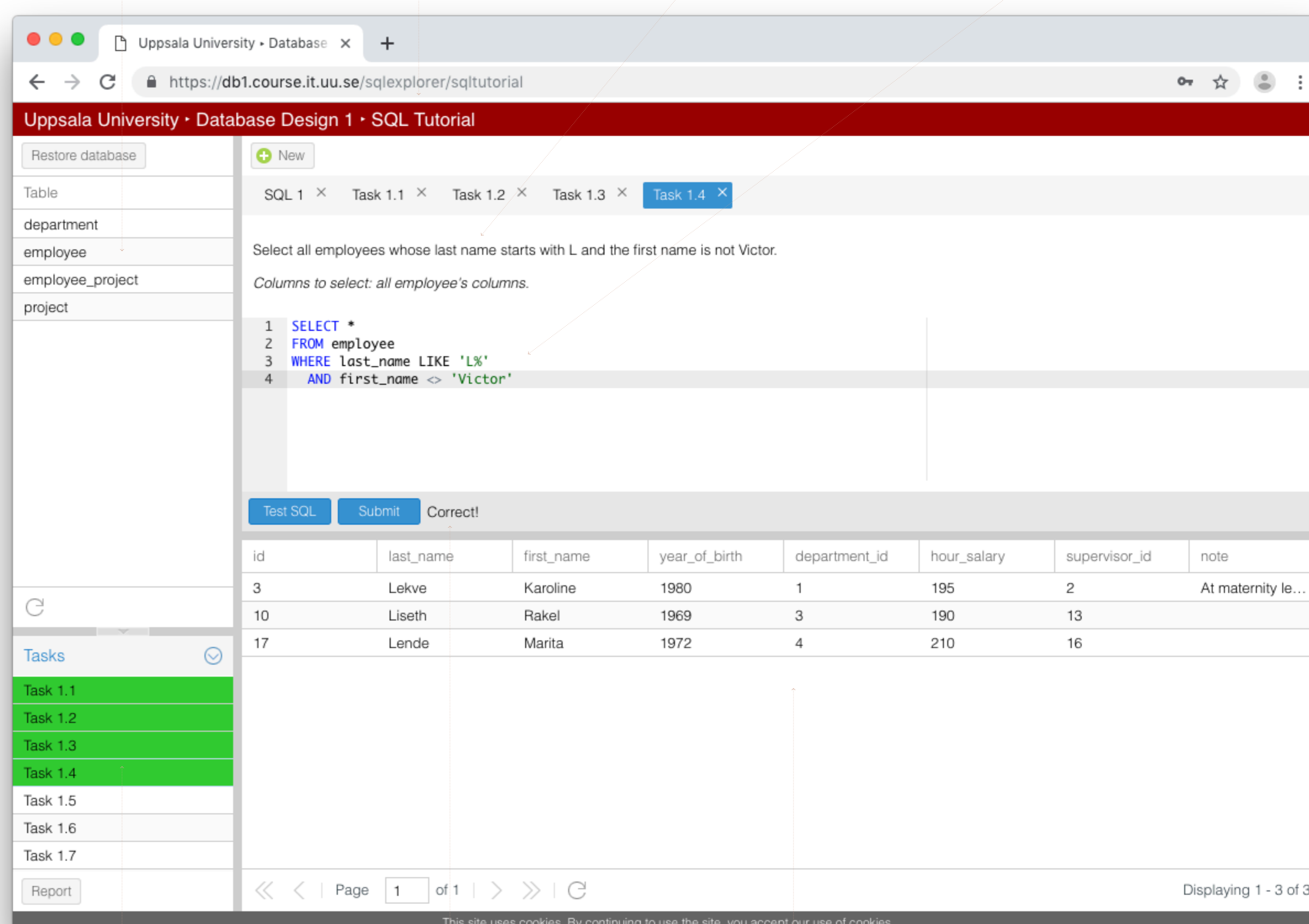
SQL EXPLORER

We developed a web-based tool for teaching and learning SQL, primarily intended to be used in-class.

- **Student interface** (the figure on the right)
 - Students use the web interface to enter and run an SQL query or statement against a sample database. Each student uses the tool anonymously, but has its own copy of the database. We also made it easy to restore the copy to the original state.
- **Tasks and automated assessment**
 - Each sample database has an accompanying set of tasks that cover different parts of SQL and vary in the difficulty. Students can submit a query and get automatic feedback on the correctness of the query.
- **Teacher interface** (the figure below)
 - The main teacher can see all submitted queries (without possibility to identify who submitted them) in real time. This allows detecting and immediately reviewing concepts not fully understood by the students.

Task	Time	Query
Task 5.5	10:32:57	SELECT title, avg(hour_salary) AS avg_hour_salary FROM employee, department WHERE department_id = department.id GROUP BY department_id HAVING avg_hour_salary = (SELECT max(avg_hour_salary) FROM (SELECT avg(hour_salary) AS avg_hour_salary FROM employee GROUP BY department_id))
Task 5.5	10:32:10	select title, max(avg) from (select title, avg(hour_salary) as avg from employee, department where department_id=department.id group by department_id)
Task 5.4	10:29:41	select * from employee e where hour_salary = (select max(hour_salary) from employee, department where d...
Task 5.3	10:25:23	select e.last_name, e.first_name, s.last_name, s.first_name from employee e left join employee s on e.supervisor_id=s.id
Task 5.3	10:24:34	select e.last_name, e.first_name, s.last_name, s.first_name from employee e, employee s where e.supervisor_id=s.id
Task 5.2	10:23:45	select * from employee where id not in (select employee_id from employee_project)

List of the tables Selected database Selected task SQL query entered by the user



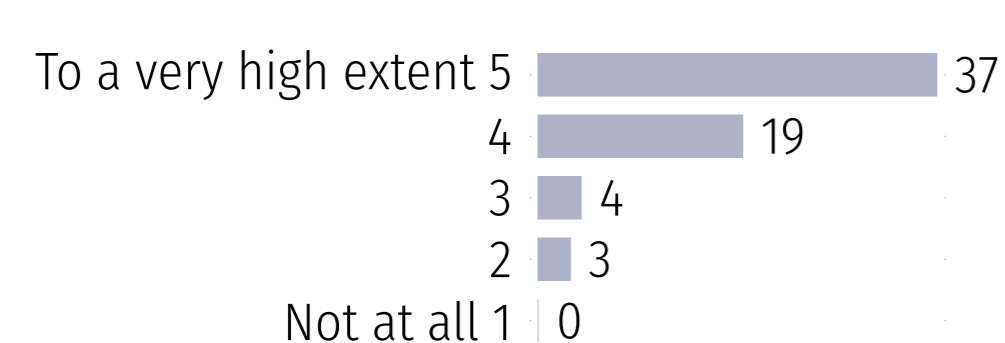
List of the tasks Feedback on the correctness Result of the query

EVALUATION BY THE STUDENTS

At the end of the second period of Fall 2018 we asked the students to evaluate their experience with the tool:

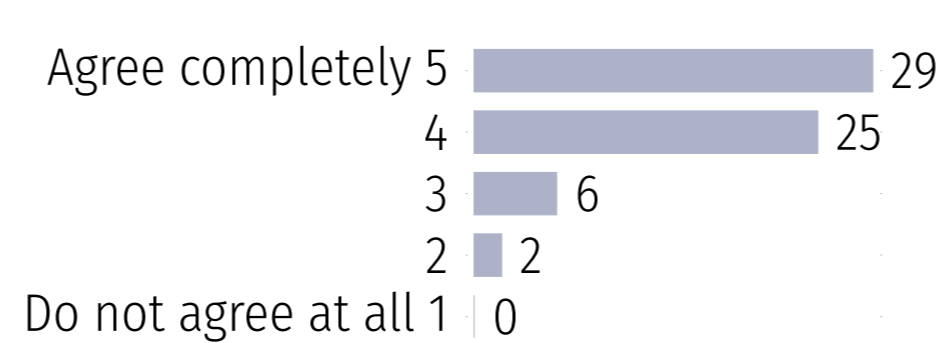
To what extent has solving the tasks in the SQL Explorer contributed to your learning of SQL queries?

(Optional, students who knew SQL from before were asked not to answer the question)



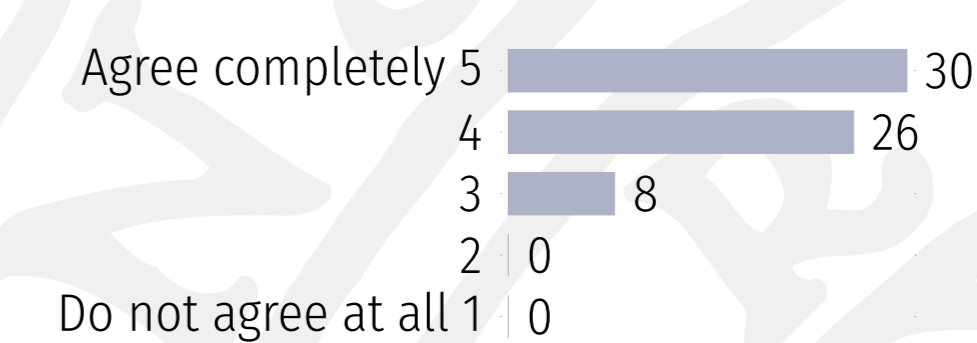
The tasks in the SQL Explorer have sufficiently covered all relevant parts of SQL queries.

(Optional)



The tasks in the SQL Explorer vary in difficulty from very easy to very difficult.

(Optional)



CONCLUSION

Using the tool during the tutorial sessions and the lab

- changed the dynamics of teaching and learning SQL in a large-class setting,
- eliminated manual checking of the correct queries and allowed the teachers to concentrate on helping and guiding the students,
- allowed us to detect and immediately review concepts not fully understood by the students.

We also found out that the students use the tool outside-of-class to practice SQL and to prepare for the exam. In total, almost 17 000 queries were submitted during the term. Results of the their "offline" inspection will be used to adjust the content of the lectures, tasks and sample databases.

FUTURE WORK

In the long term we wish to:

- extend the automated assessment to be able to detect common mistakes and to provide hints,
- replace the SQL part of the written final exam by a computer-based exam using SQL Explorer,
- extend the tool to be able to evaluate students' progress and to propose next tasks to work on,
- add a few sample databases with tasks that students can use outside-of-class,
- release the software under an open source license (GPL).