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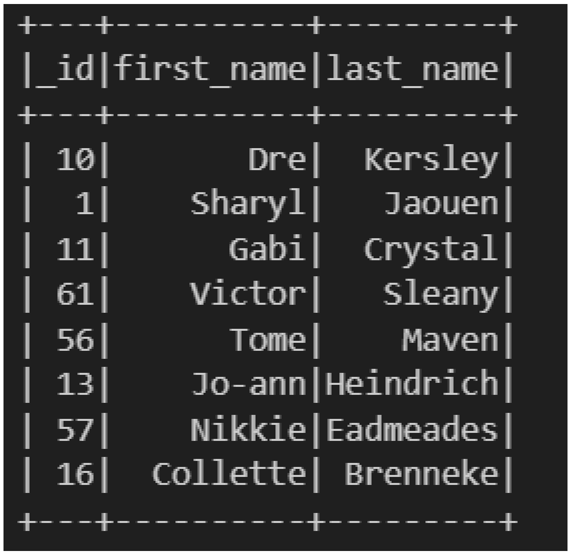
Report - Assignment 1

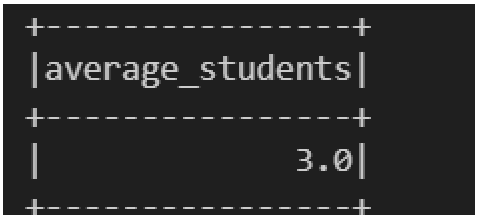
3. Query Implementation using Apache Spark

1) Fetching all students enrolled in a specific course.



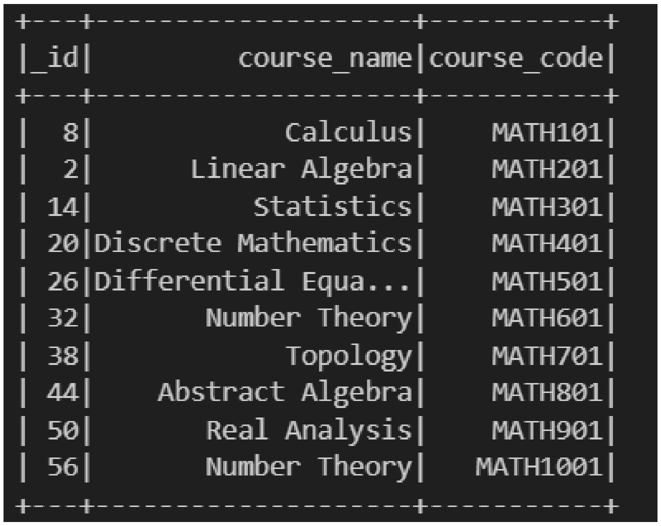
```
+---+----------+---------+
|_id|first_name|last_name|
+---+----------+---------+
| 10|       Dre|  Kersley|
|  1|    Sharyl|   Jaouen|
| 11|      Gabi|  Crystal|
| 61|    Victor|   Sleany|
| 56|      Tome|    Maven|
| 13|    Jo-ann|Heindrich|
| 57|    Nikkie|Eadmeades|
| 16|  Collette| Brenneke|
+---+----------+---------+
```

2) Calculating the average number of students enrolled in courses offered by a particular instructor at the university.



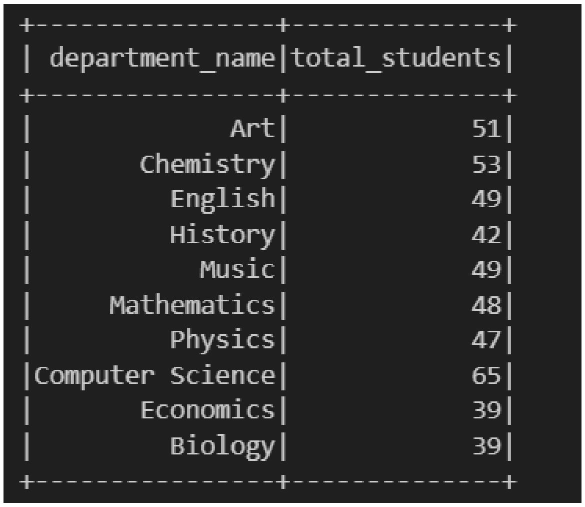
```
+----------------+
|average_students|
+----------------+
|             3.0|
+----------------+
```

3) Listing all courses offered by a specific department.



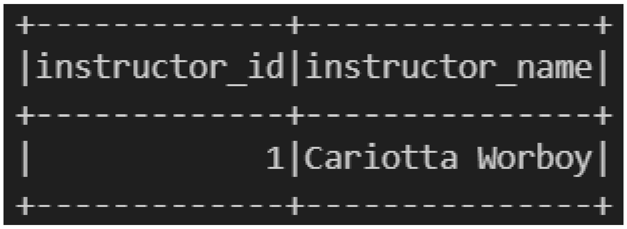
```
+---+--------------------+-----------+
|_id|         course_name|course_code|
+---+--------------------+-----------+
|  8|            Calculus|    MATH101|
|  2|      Linear Algebra|    MATH201|
| 14|          Statistics|    MATH301|
| 20|Discrete Mathematics|    MATH401|
| 26|Differential Equa...|    MATH501|
| 32|       Number Theory|    MATH601|
| 38|            Topology|    MATH701|
| 44|    Abstract Algebra|    MATH801|
| 50|       Real Analysis|    MATH901|
| 56|       Number Theory|   MATH1001|
+---+--------------------+-----------+
```

4) Finding the total number of students per department.



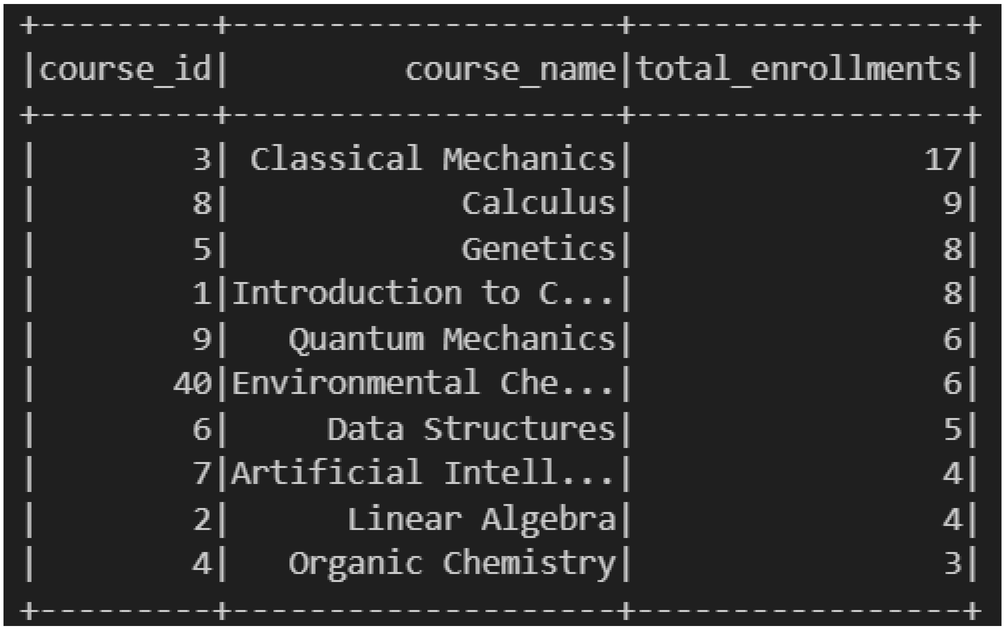
```
+----------------+--------------+
| department_name|total_students|
+----------------+--------------+
|             Art|            51|
|       Chemistry|            53|
|         English|            49|
|         History|            42|
|           Music|            49|
|     Mathematics|            48|
|         Physics|            47|
|Computer Science|            65|
|       Economics|            39|
|         Biology|            39|
+----------------+--------------+
```

5) Finding instructors who have taught all the BTech CSE core courses sometime during their tenure at the university.



```
+-------------+---------------+
|instructor_id|instructor_name|
+-------------+---------------+
|            1|Cariotta Worboy|
+-------------+---------------+
```

6) Finding top-10 courses with the highest enrollments.



```
+---------+--------------------+-----------------+
|course_id|         course_name|total_enrollments|
+---------+--------------------+-----------------+
|        3| Classical Mechanics|               17|
|        8|            Calculus|                9|
|        5|            Genetics|                8|
|        1|Introduction to C...|                8|
|        9|   Quantum Mechanics|                6|
|       40|Environmental Che...|                6|
|        6|     Data Structures|                5|
|        7|Artificial Intell...|                4|
|        2|      Linear Algebra|                4|
|        4|   Organic Chemistry|                3|
+---------+--------------------+-----------------+
```

4. Optimizations

Techniques Used:

1. **Indexing**

```
db.instructors.createIndex({"instructor_id": 1 })
db.students.createIndex({ "student_id": 1 })
db.courses.createIndex({ "course_id": 1 })
db.courses.createIndex({ "course_id": 1, "instructor_id": 1 })
```

Indexes in MongoDB enable fast document retrieval by allowing quick access to relevant records without full collection scans. Indexing fields like `student_id`, `course_id`, and `instructor_id` decreases search times and input/output operations, enhancing performance. Compound indexes (e.g., on `course_id` and `instructor_id`) further improve efficiency for multi-field queries, reducing post-retrieval filtering. This is vital for maintaining consistent performance in read-heavy applications as the database scales

2. **Partitioning (In Spark)**

On basis of columns:

```
courses_partitioned_df = courses_df.repartition(n,"_id")
students_df = students_df.repartition(n,"_id")
instructors_partitioned_df = instructors_df.repartition(n,"_id")
```

S. No.	Exec_time_before_optimization	Exec_time_after_optimization
1	0.3738 seconds	0.2509 seconds
2	0.9351 seconds	0.4811seconds
3	0.1162 seconds	0.1156 seconds
4	0.3713 seconds	0.309 seconds
5	0.5245 seconds	0.2633seconds
6	0.3862 seconds	0.3501 seconds

It can be seen these optimizations lead to some decrease in execution time, but they can significantly perform well particularly when used with larger datasets or in distributed computing settings. However, with smaller datasets, the overhead associated with creating indexes or repartitioning may occasionally cause longer query execution times. So, overall results don’t show too much of a difference!