Data Analysis and Integration

ETL tools and SQL queries

Pentaho Data Integration

- Transformations work in “streaming” mode
  - the first row could reach the output before the second row is read from input
  - there are exceptions, e.g. when some aggregation on multiple rows needs to be performed
- Transformations can be saved and executed many times
- Transformations can become quite complex

SQL query

- number of employees in each department

curr_dept_emp

```
+--------+---------+
| emp_no | dept_no |
+--------+---------+
|  10721 | d009    |
|  11260 | d009    |
|  11371 | d005    |
|  11693 | d005    |
|  13816 | d005    |
|  14007 | d002    |
|  14083 | d004    |
|  14791 | d005    |
|  17698 | d005    |
|  17739 | d005    |
|    ... |  ...    |
+--------+---------+
```

departments

```
+---------+--------------------+
| dept_no | dept_name          |
+---------+--------------------+
| d009    | Customer Service   |
| d005    | Development        |
| d002    | Finance            |
| d003    | Human Resources    |
| d001    | Marketing          |
| d004    | Production         |
| d006    | Quality Management |
| d008    | Research           |
| d007    | Sales              |
+---------+--------------------+
```

SQL query

- number of employees in each department

```
select *
from curr_dept_emp as a, departments as b
where a.dept_no = b.dept_no;
```

```
+--------+---------+---------+------------------+
| emp_no | dept_no | dept_no | dept_name        |
+--------+---------+---------+------------------+
|  10721 | d009    | d009    | Customer Service |
|  11260 | d009    | d009    | Customer Service |
|  11371 | d005    | d005    | Development      |
|  11693 | d005    | d005    | Development      |
|  13816 | d005    | d005    | Development      |
|  14007 | d002    | d002    | Finance          |
|  14083 | d004    | d004    | Production       |
|  14791 | d005    | d005    | Development      |
|  17698 | d005    | d005    | Development      |
|  17739 | d005    | d005    | Development      |
+--------+---------+---------+------------------+
10 rows in set (0.00 sec)
```

SQL query

- number of employees in each department

```
select b.dept_no, b.dept_name, count(emp_no)
from curr_dept_emp as a, departments as b
where a.dept_no = b.dept_no
group by b.dept_no, b.dept_name;
```

```
+---------+--------------------+---------------+
| dept_no | dept_name          | count(emp_no) |
+---------+--------------------+---------------+
| d001    | Marketing          |            15 |
| d002    | Finance            |            18 |
| d003    | Human Resources    |            10 |
| d004    | Production         |            44 |
| d005    | Development        |            62 |
| d006    | Quality Management |            18 |
| d007    | Sales              |            42 |
| d008    | Research           |            14 |
| d009    | Customer Service   |            29 |
+---------+--------------------+---------------+
9 rows in set (0.00 sec)
```

SQL query

- number of employees in each department

```
select b.dept_no, b.dept_name, count(emp_no) as count_emp_no
from curr_dept_emp as a, departments as b
where a.dept_no = b.dept_no
group by b.dept_no, b.dept_name
having count_emp_no >= 40;
```

```
+---------+-------------+--------------+
| dept_no | dept_name   | count_emp_no |
+---------+-------------+--------------+
| d004    | Production  |           44 |
| d005    | Development |           62 |
| d007    | Sales       |           42 |
+---------+-------------+--------------+
3 rows in set (0.00 sec)
```

SQL query

- number of employees in each department

```
select b.dept_no, b.dept_name, count(emp_no) as count_emp_no
from curr_dept_emp as a, departments as b
where a.dept_no = b.dept_no
group by b.dept_no, b.dept_name
having count_emp_no >= 40
order by count_emp_no desc;
```

```
+---------+-------------+--------------+
| dept_no | dept_name   | count_emp_no |
+---------+-------------+--------------+
| d005    | Development |           62 |
| d004    | Production  |           44 |
| d007    | Sales       |           42 |
+---------+-------------+--------------+
3 rows in set (0.00 sec)
```

SQL query

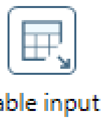
- doing the same query with an ETL tool

```
select b.dept_no, b.dept_name, count(emp_no) as count_emp_no
from curr_dept_emp as a, departments as b
where a.dept_no = b.dept_no
group by b.dept_no, b.dept_name
having count_emp_no >= 40
order by count_emp_no desc;
```

  – how to do it?

Table input

select a.dept_no, b.dept_name, **count**(a.emp_no) **as** count_emp_no
from curr_dept_emp **as** a, departments **as** b
where a.dept_no = b.dept_no
group by a.dept_no, b.dept_name
having count_emp_no >= 40
order by count_emp_no **desc**;



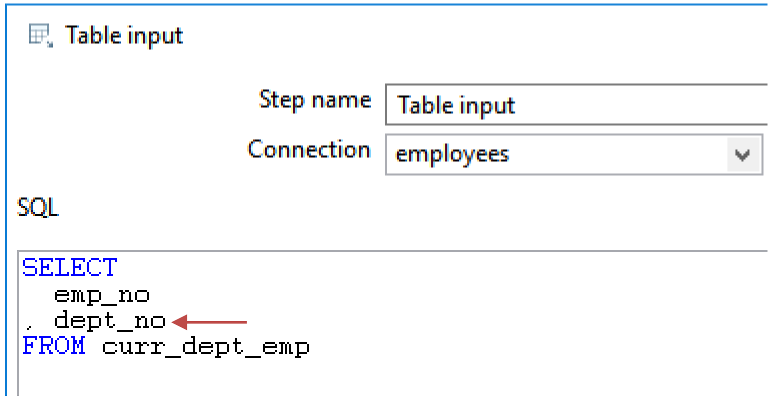


Table input

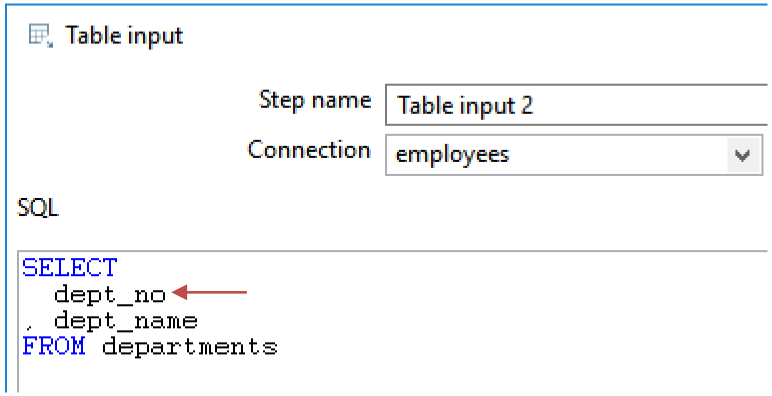
Step name: Table input
Connection: employees

SQL

```
SELECT
   emp_no
 , dept_no
FROM curr_dept_emp
```

Table input

```
select a.dept_no, b.dept_name, count(a.emp_no) as count_emp_no
from curr_dept_emp as a, departments as b
where a.dept_no = b.dept_no
group by a.dept_no, b.dept_name
having count_emp_no >= 40
order by count_emp_no desc;
```



Step name: Table input 2

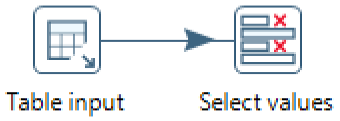
Connection: employees

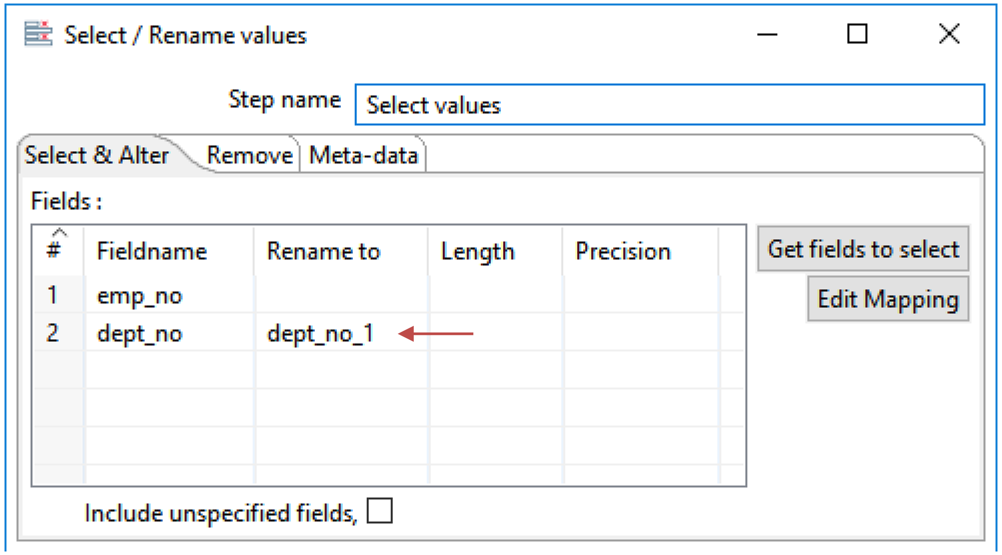
SQL

```
SELECT
  dept_no
, dept_name
FROM departments
```

Select values

```
select a.dept_no, b.dept_name, count(a.emp_no) as count_emp_no
from curr_dept_emp as a, departments as b
where a.dept_no = b.dept_no
group by a.dept_no, b.dept_name
having count_emp_no >= 40
order by count_emp_no desc;
```





Step name: Select values

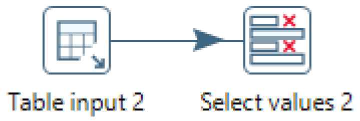
Fields :

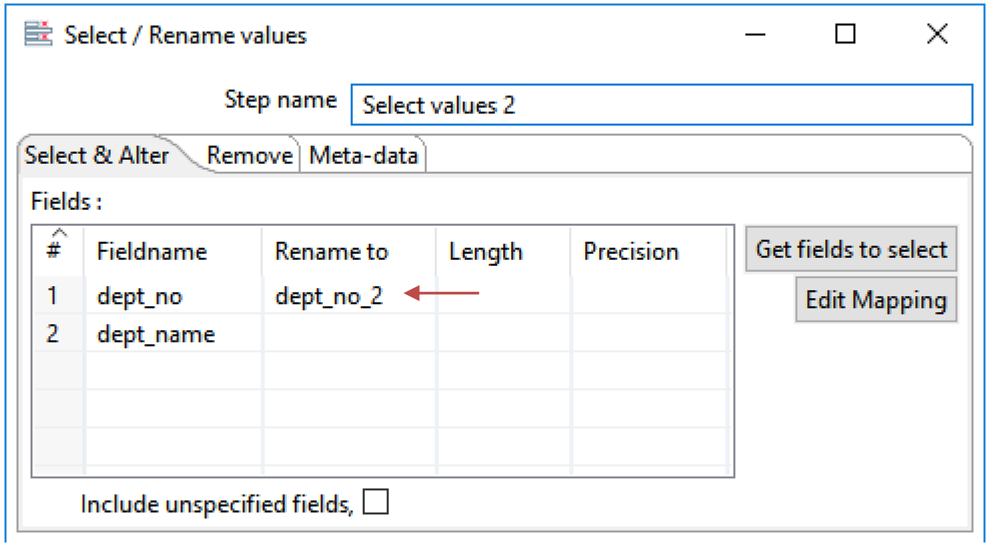
#	Fieldname	Rename to	Length	Precision
1	emp_no			
2	dept_no	dept_no_1		

Include unspecified fields, ☐

Select values

```
select a.dept_no, b.dept_name, count(a.emp_no) as count_emp_no
from curr_dept_emp as a, departments as b
where a.dept_no = b.dept_no
group by a.dept_no, b.dept_name
having count_emp_no >= 40
order by count_emp_no desc;
```





Step name: Select values 2

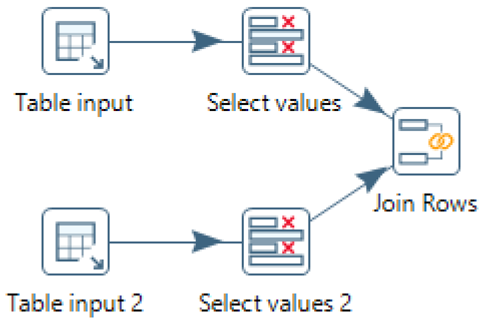
Fields :

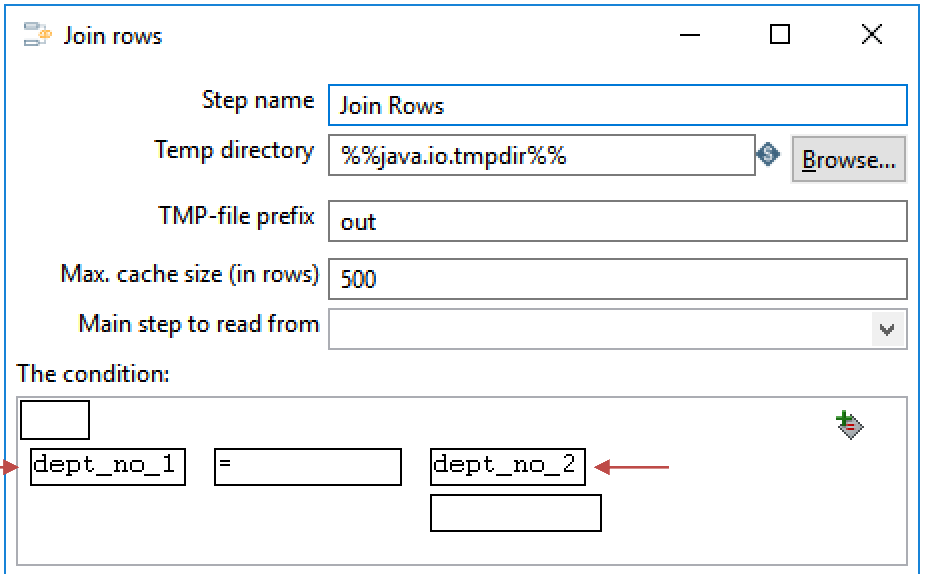
#	Fieldname	Rename to	Length	Precision
1	dept_no	dept_no_2		
2	dept_name			

Include unspecified fields, ☐

Join rows

select a.dept_no, b.dept_name, **count**(a.emp_no) **as** count_emp_no
from curr_dept_emp **as** a, departments **as** b
where a.dept_no = b.dept_no
group by a.dept_no, b.dept_name
having count_emp_no >= 40
order by count_emp_no **desc**;





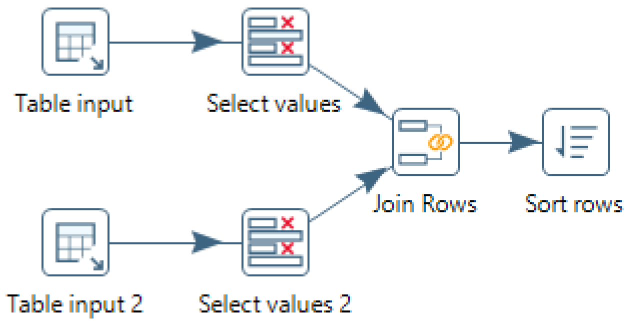
Step name	Join Rows
Temp directory	%%java.io.tmpdir%%
TMP-file prefix	out
Max. cache size (in rows)	500
Main step to read from	

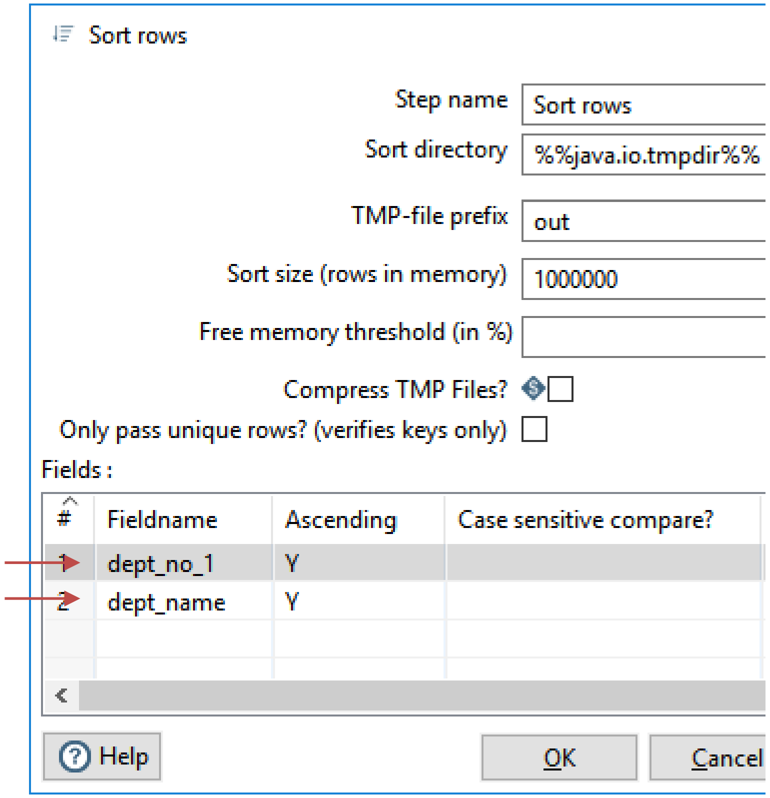
The condition:

dept_no_1 = dept_no_2

Sort rows

select a.dept_no, b.dept_name, **count**(a.emp_no) **as** count_emp_no
from curr_dept_emp **as** a, departments **as** b
where a.dept_no = b.dept_no
group by a.dept_no, b.dept_name
having count_emp_no >= 40
order by count_emp_no **desc**;




Sort rows

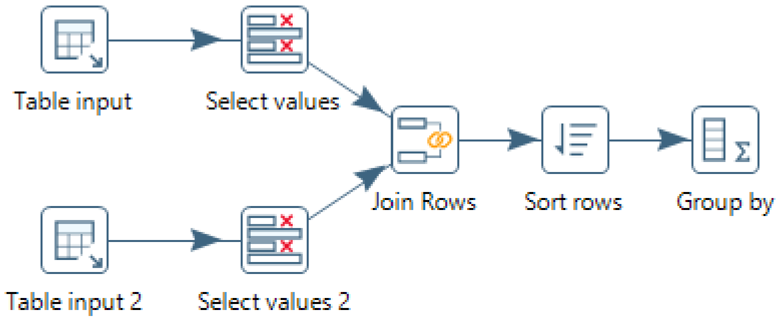
Step name	Sort rows
Sort directory	%%java.io.tmpdir%%
TMP-file prefix	out
Sort size (rows in memory)	1000000
Free memory threshold (in %)	
Compress TMP Files?	☐
Only pass unique rows? (verifies keys only)	☐

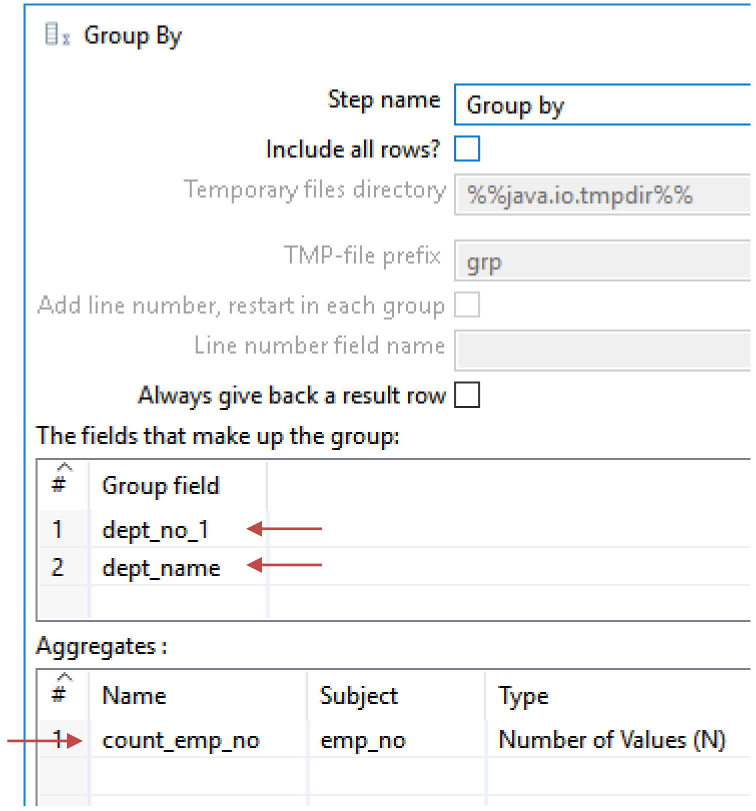
Fields :

#	Fieldname	Ascending	Case sensitive compare?
1	dept_no_1	Y	
2	dept_name	Y	

Group by

```
select a.dept_no, b.dept_name, count(a.emp_no) as count_emp_no
from curr_dept_emp as a, departments as b
where a.dept_no = b.dept_no
group by a.dept_no, b.dept_name
having count_emp_no >= 40
order by count_emp_no desc;
```





Group By

Step name	Group by
Include all rows?	☐
Temporary files directory	%%java.io.tmpdir%%
TMP-file prefix	grp
Add line number, restart in each group	☐
Line number field name	
Always give back a result row	☐

The fields that make up the group:

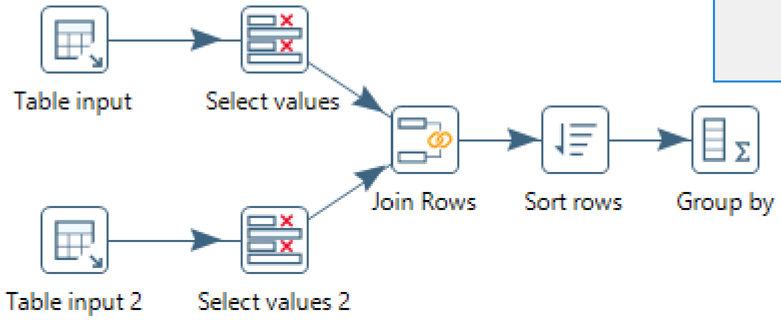
#	Group field
1	dept_no_1
2	dept_name

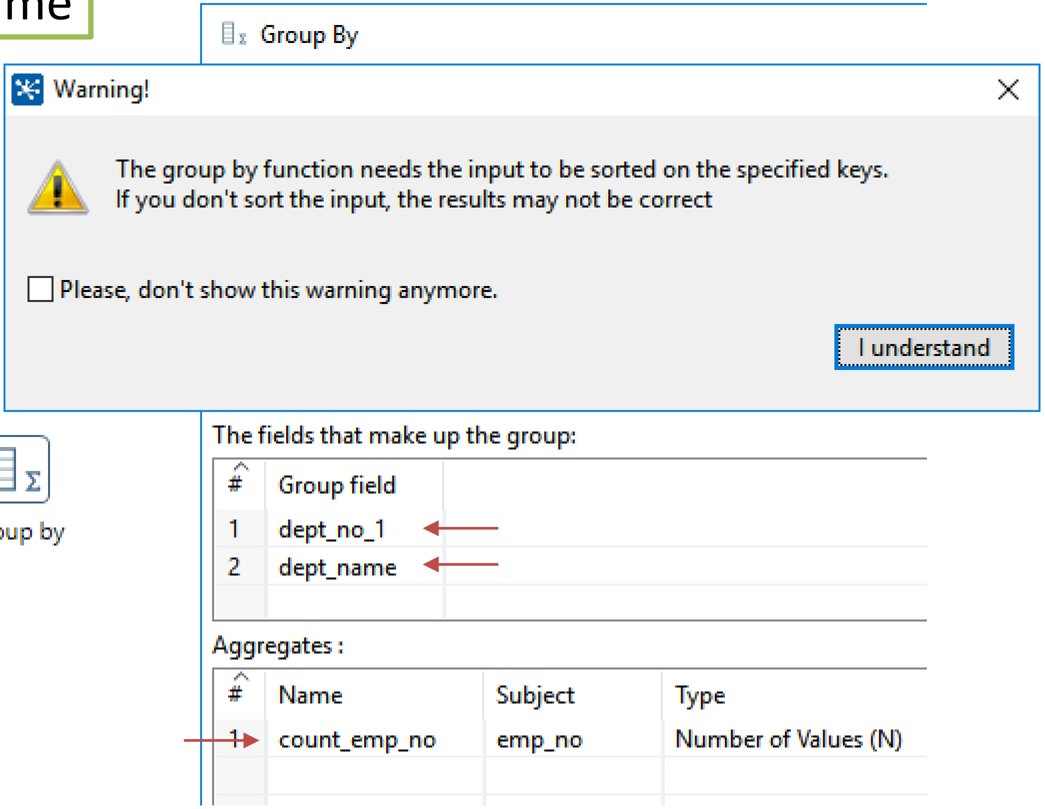
Aggregates :

#	Name	Subject	Type
1	count_emp_no	emp_no	Number of Values (N)

Group by

```
select a.dept_no, b.dept_name, count(a.emp_no) as count_emp_no
from curr_dept_emp as a, departments as b
where a.dept_no = b.dept_no
group by a.dept_no, b.dept_name
having count_emp_no >= 40
order by count_emp_no desc;
```





Group By

Warning!

The group by function needs the input to be sorted on the specified keys.
If you don't sort the input, the results may not be correct

☐ Please, don't show this warning anymore.

The fields that make up the group:

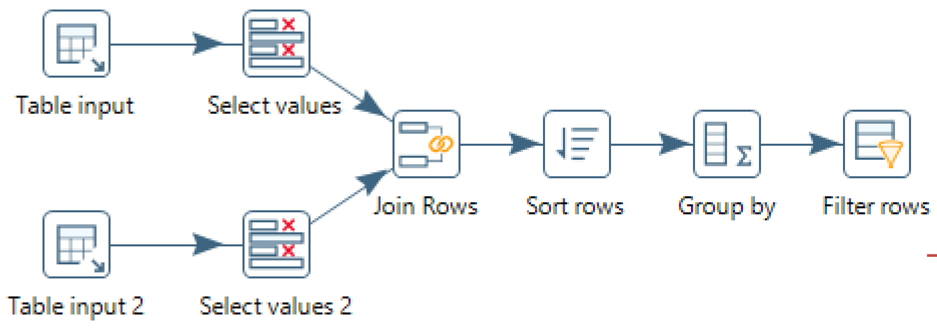
#	Group field
1	dept_no_1
2	dept_name

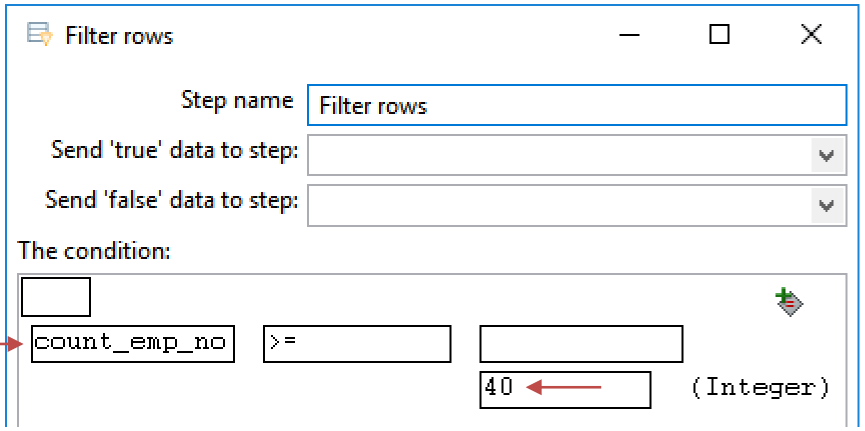
Aggregates :

#	Name	Subject	Type
1	count_emp_no	emp_no	Number of Values (N)

Filter rows

select a.dept_no, b.dept_name, **count**(a.emp_no) **as** count_emp_no
from curr_dept_emp **as** a, departments **as** b
where a.dept_no = b.dept_no
group by a.dept_no, b.dept_name
having count_emp_no >= 40
order by count_emp_no **desc**;



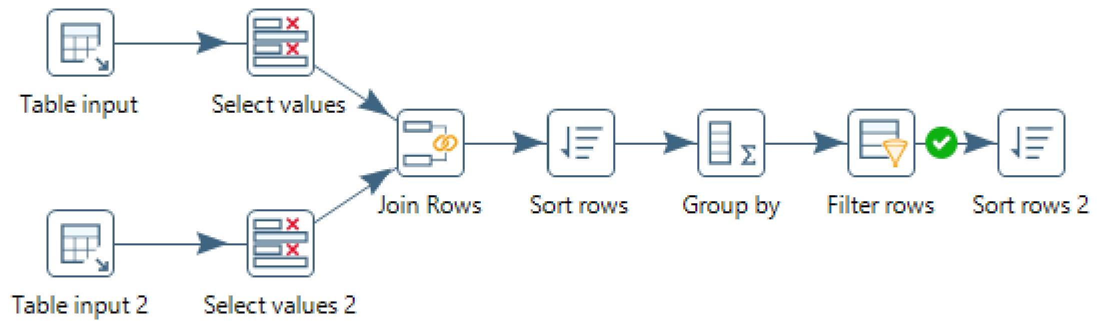

Filter rows

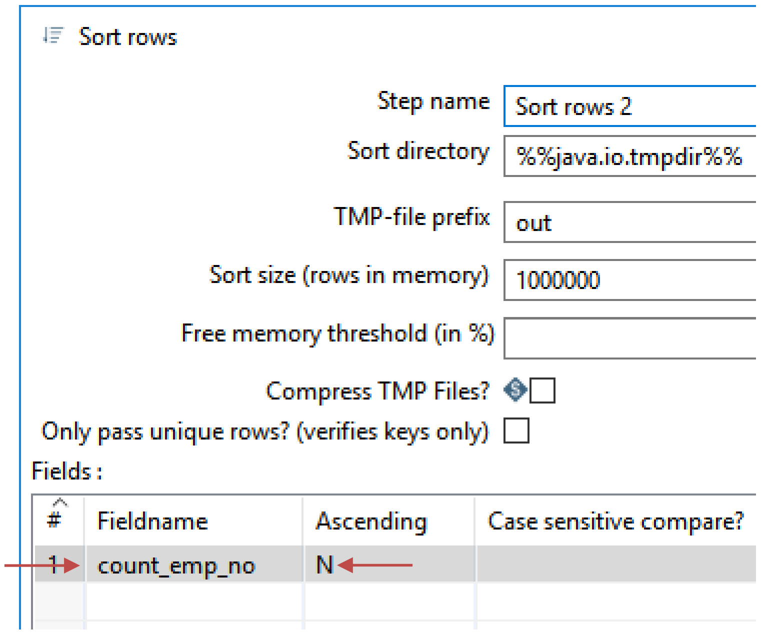
Step name: Filter rows
Send 'true' data to step:
Send 'false' data to step:
The condition:

```
count_emp_no   >=
                    40   (Integer)
```

Filter rows

select a.dept_no, b.dept_name, **count**(a.emp_no) **as** count_emp_no
from curr_dept_emp **as** a, departments **as** b
where a.dept_no = b.dept_no
group by a.dept_no, b.dept_name
having count_emp_no >= 40
order by count_emp_no **desc**;



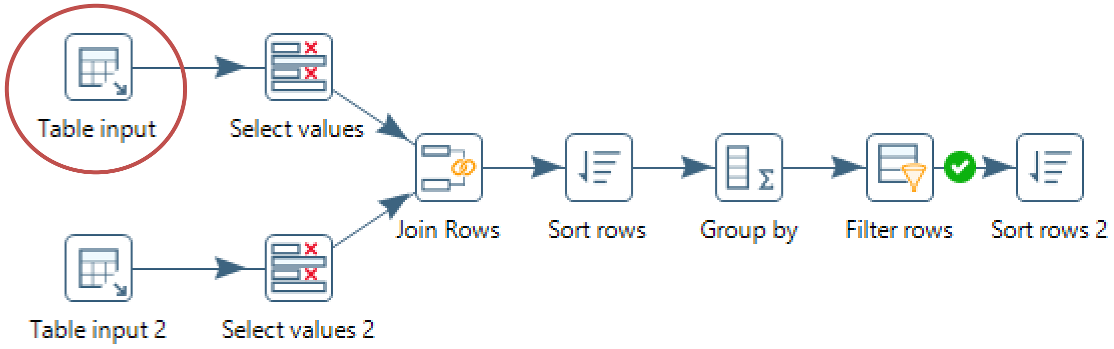

Sort rows

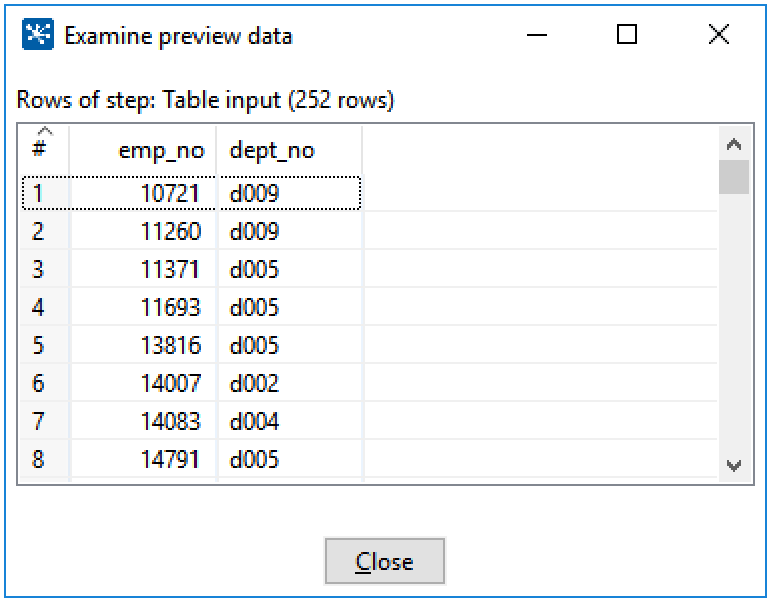
Step name	Sort rows 2
Sort directory	%%java.io.tmpdir%%
TMP-file prefix	out
Sort size (rows in memory)	1000000
Free memory threshold (in %)	
Compress TMP Files?	☐
Only pass unique rows? (verifies keys only)	☐

Fields :

#	Fieldname	Ascending	Case sensitive compare?
1	count_emp_no	N	

Preview

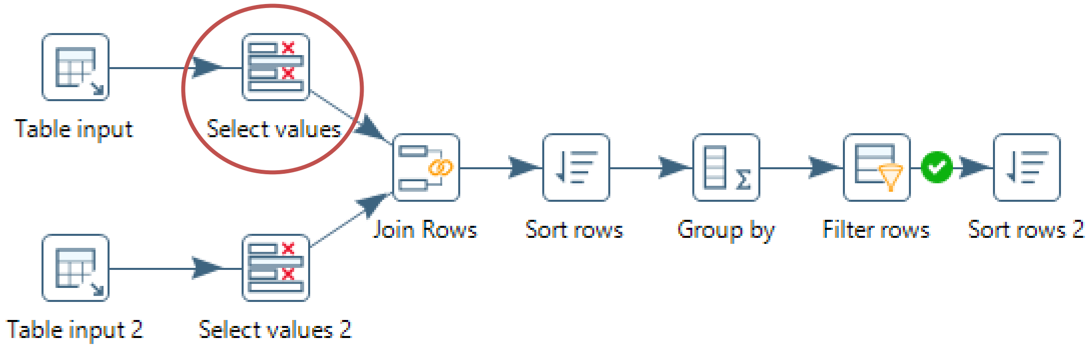


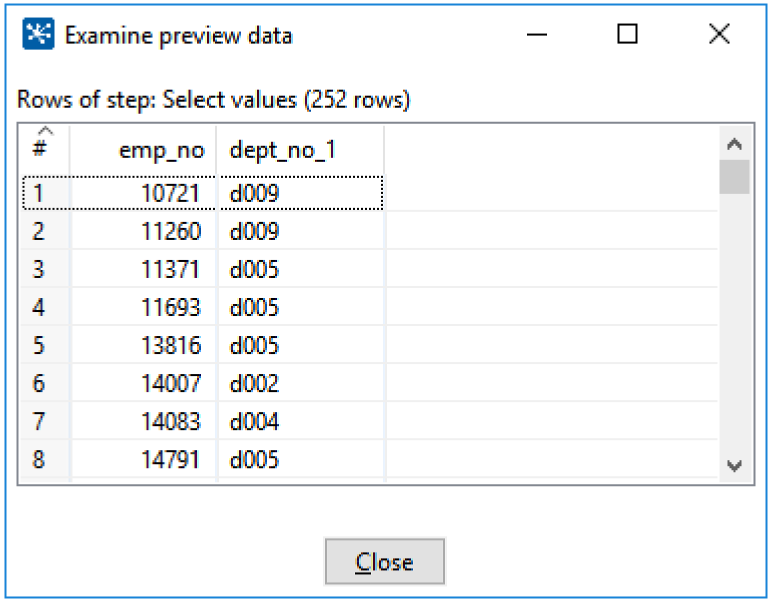


Rows of step: Table input (252 rows)

#	emp_no	dept_no
1	10721	d009
2	11260	d009
3	11371	d005
4	11693	d005
5	13816	d005
6	14007	d002
7	14083	d004
8	14791	d005

Preview

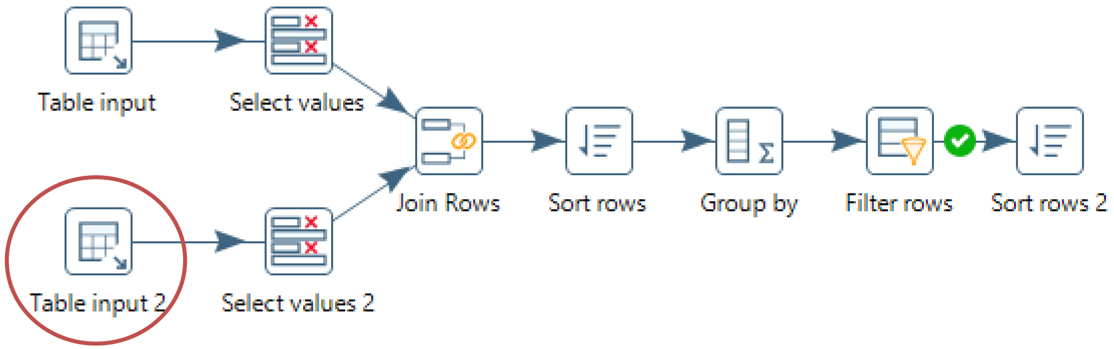


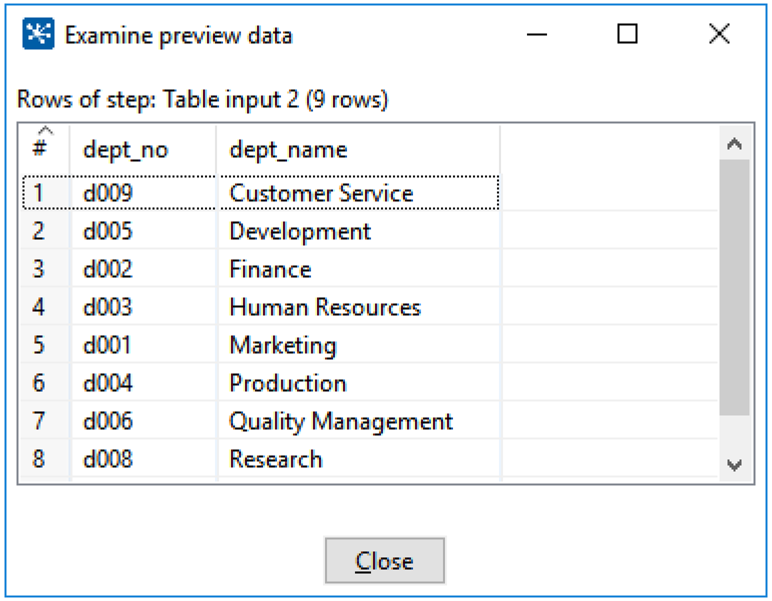


Rows of step: Select values (252 rows)

#	emp_no	dept_no_1
1	10721	d009
2	11260	d009
3	11371	d005
4	11693	d005
5	13816	d005
6	14007	d002
7	14083	d004
8	14791	d005

Preview

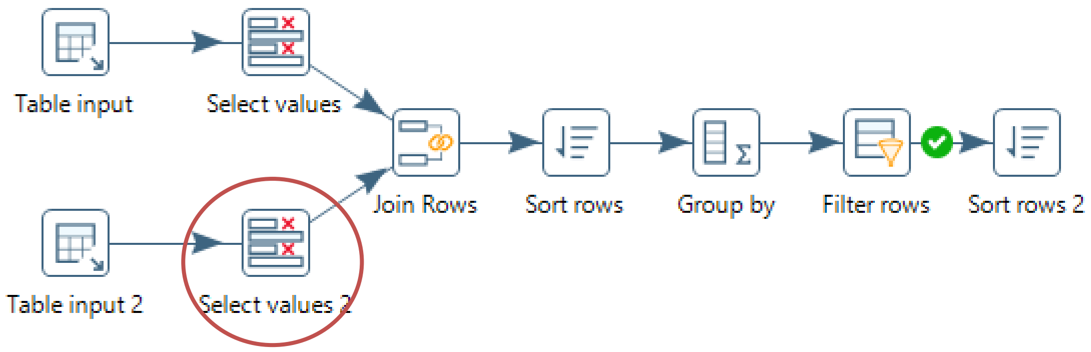


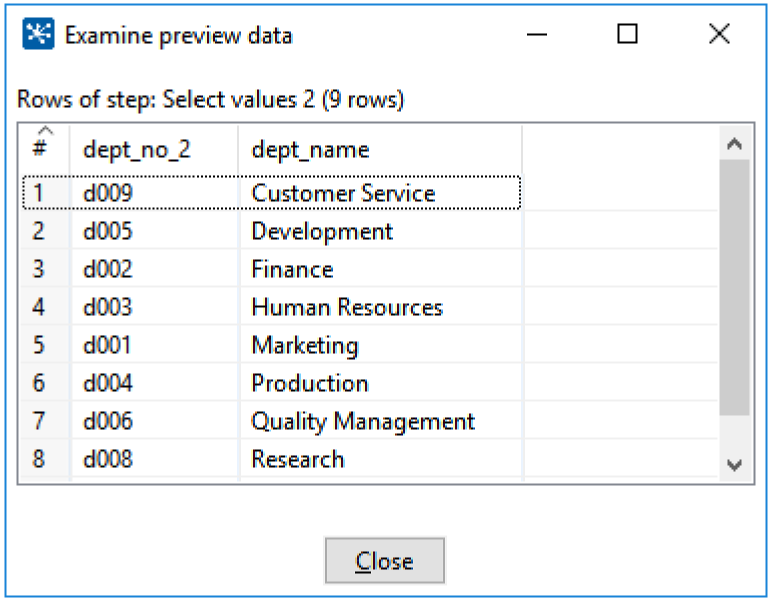

Examine preview data

Rows of step: Table input 2 (9 rows)

#	dept_no	dept_name
1	d009	Customer Service
2	d005	Development
3	d002	Finance
4	d003	Human Resources
5	d001	Marketing
6	d004	Production
7	d006	Quality Management
8	d008	Research

Preview

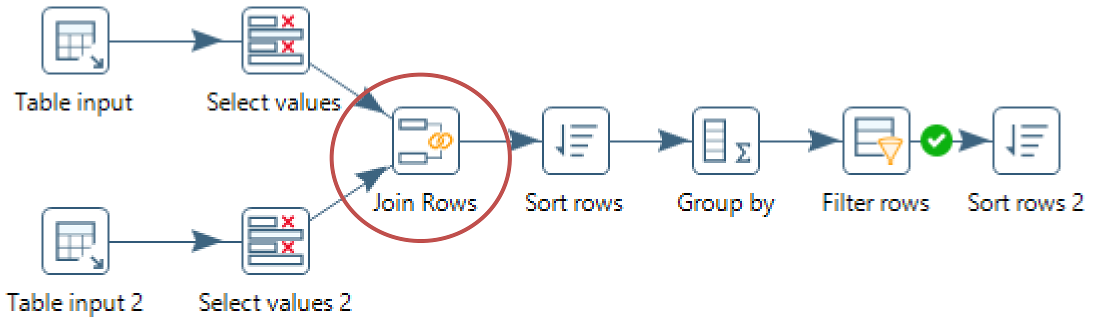


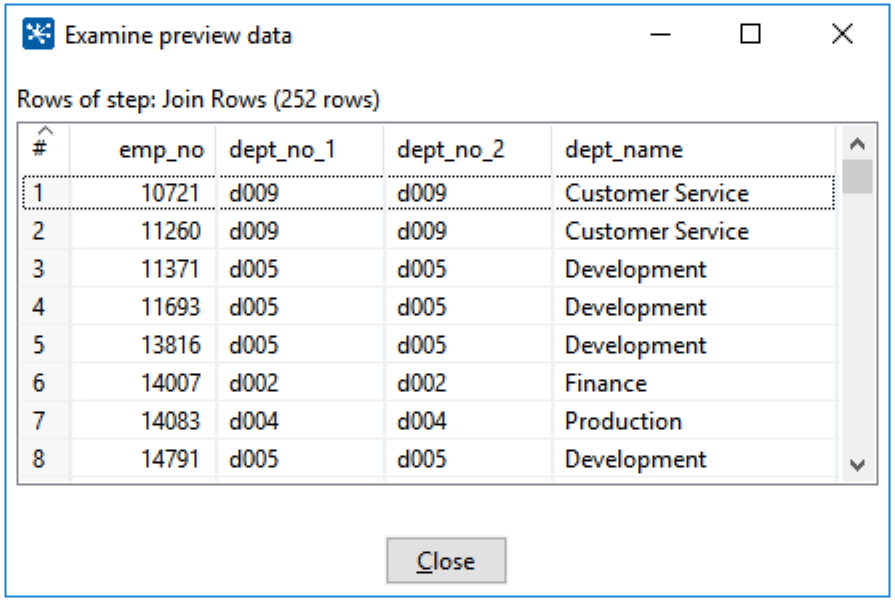


Rows of step: Select values 2 (9 rows)

#	dept_no_2	dept_name
1	d009	Customer Service
2	d005	Development
3	d002	Finance
4	d003	Human Resources
5	d001	Marketing
6	d004	Production
7	d006	Quality Management
8	d008	Research

Preview

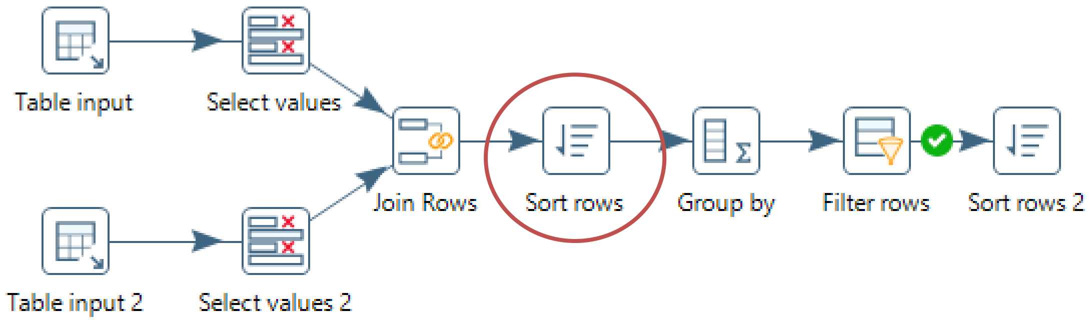


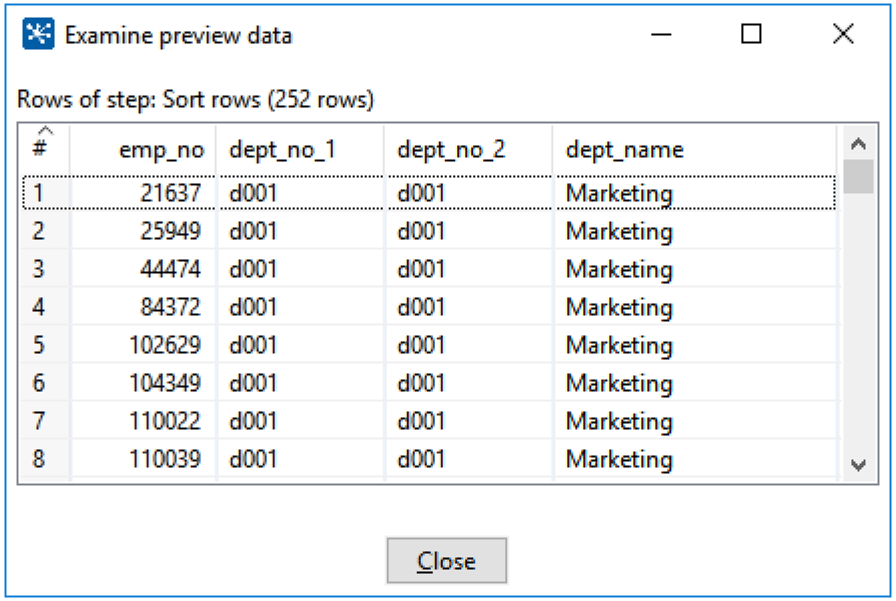


Rows of step: Join Rows (252 rows)

#	emp_no	dept_no_1	dept_no_2	dept_name
1	10721	d009	d009	Customer Service
2	11260	d009	d009	Customer Service
3	11371	d005	d005	Development
4	11693	d005	d005	Development
5	13816	d005	d005	Development
6	14007	d002	d002	Finance
7	14083	d004	d004	Production
8	14791	d005	d005	Development

Preview

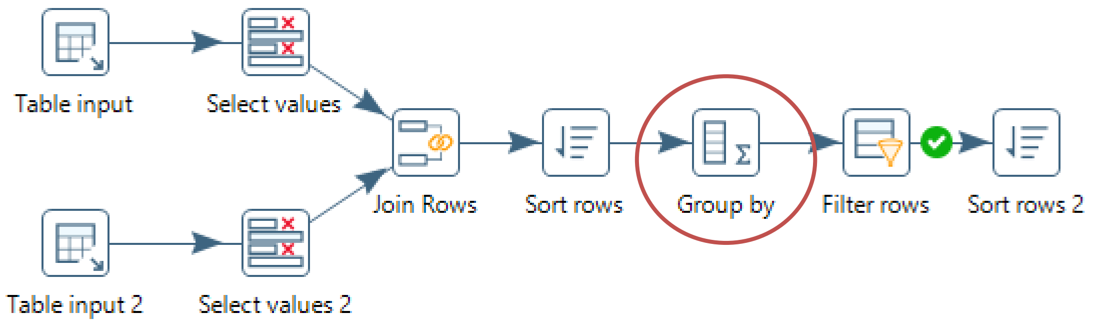


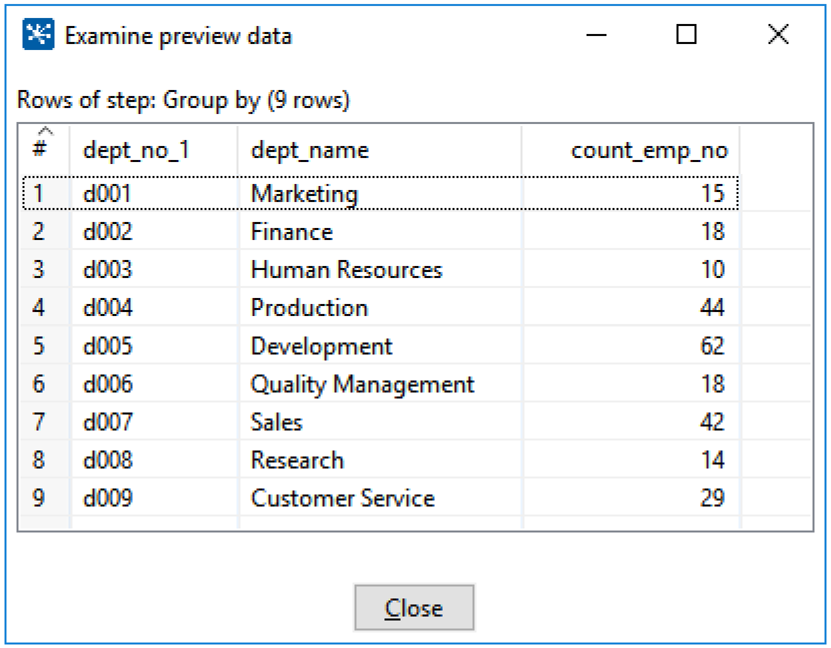


Rows of step: Sort rows (252 rows)

#	emp_no	dept_no_1	dept_no_2	dept_name
1	21637	d001	d001	Marketing
2	25949	d001	d001	Marketing
3	44474	d001	d001	Marketing
4	84372	d001	d001	Marketing
5	102629	d001	d001	Marketing
6	104349	d001	d001	Marketing
7	110022	d001	d001	Marketing
8	110039	d001	d001	Marketing

Preview

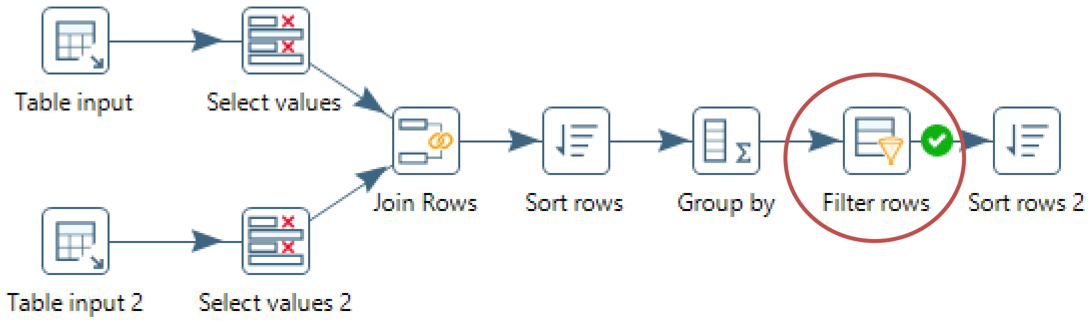


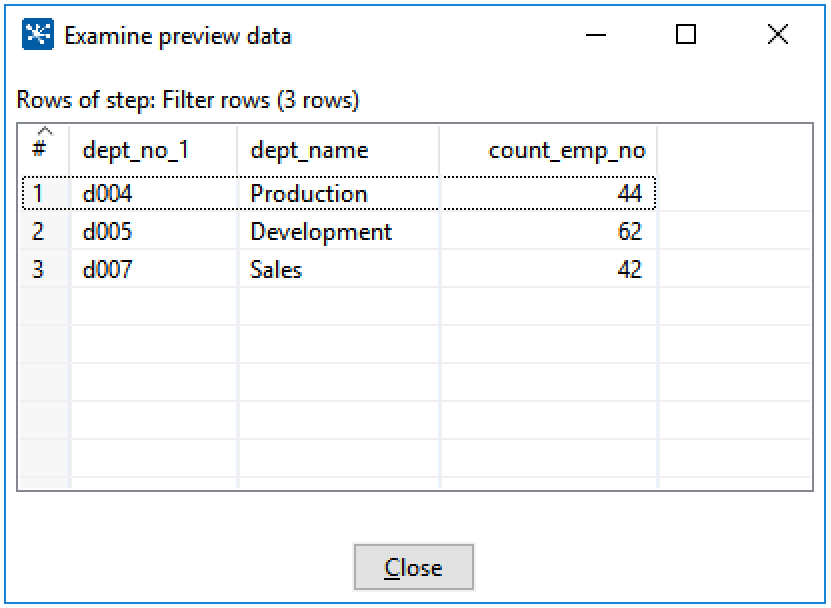


Rows of step: Group by (9 rows)

#	dept_no_1	dept_name	count_emp_no
1	d001	Marketing	15
2	d002	Finance	18
3	d003	Human Resources	10
4	d004	Production	44
5	d005	Development	62
6	d006	Quality Management	18
7	d007	Sales	42
8	d008	Research	14
9	d009	Customer Service	29

Preview

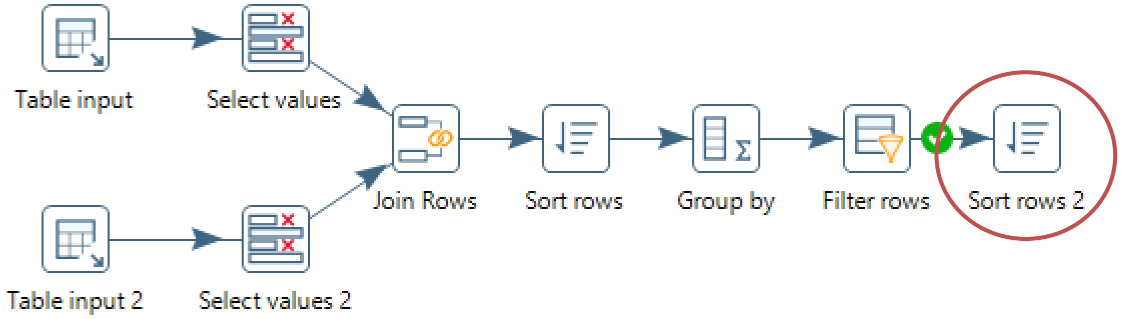


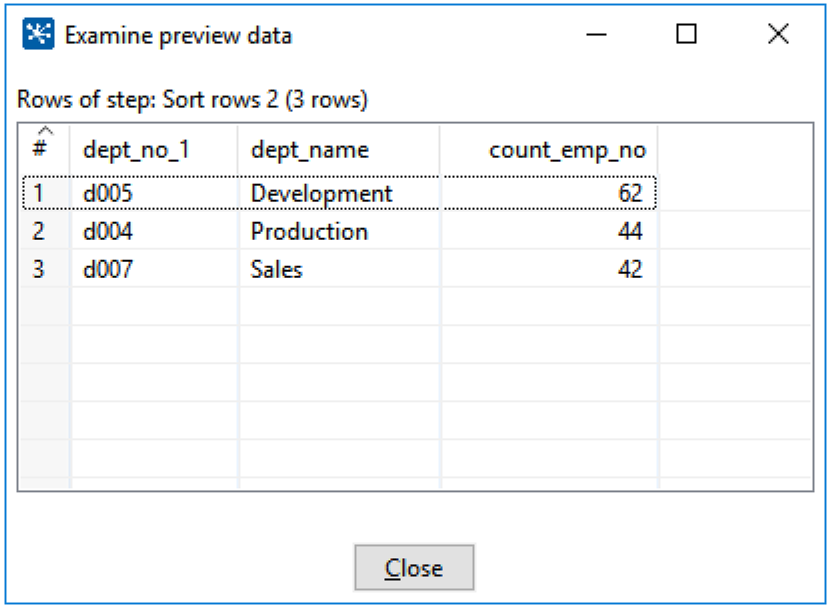


Rows of step: Filter rows (3 rows)

#	dept_no_1	dept_name	count_emp_no
1	d004	Production	44
2	d005	Development	62
3	d007	Sales	42

Preview



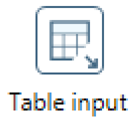


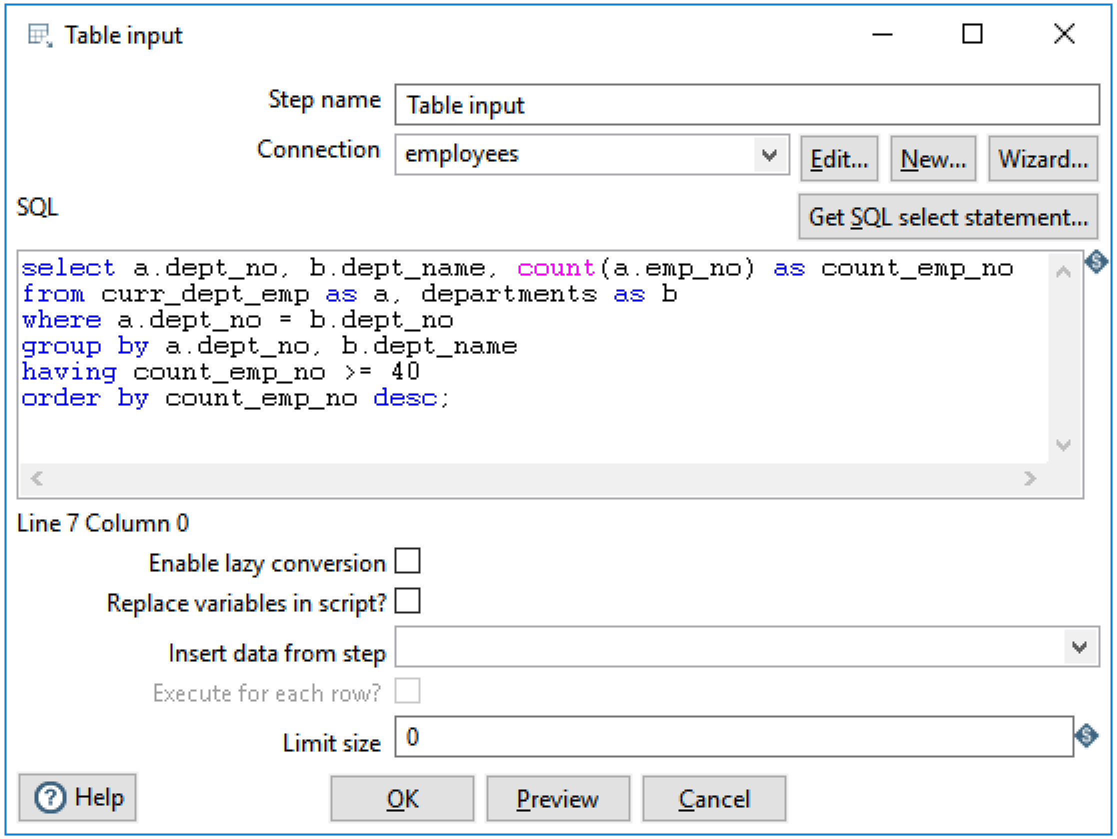
Rows of step: Sort rows 2 (3 rows)

#	dept_no_1	dept_name	count_emp_no
1	d005	Development	62
2	d004	Production	44
3	d007	Sales	42

Alternatives

- A completely different solution





Step name: Table input

Connection: employees

```
select a.dept_no, b.dept_name, count(a.emp_no) as count_emp_no
from curr_dept_emp as a, departments as b
where a.dept_no = b.dept_no
group by a.dept_no, b.dept_name
having count_emp_no >= 40
order by count_emp_no desc;
```

Line 7 Column 0

Enable lazy conversion ☐

Replace variables in script? ☐

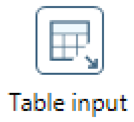
Insert data from step:

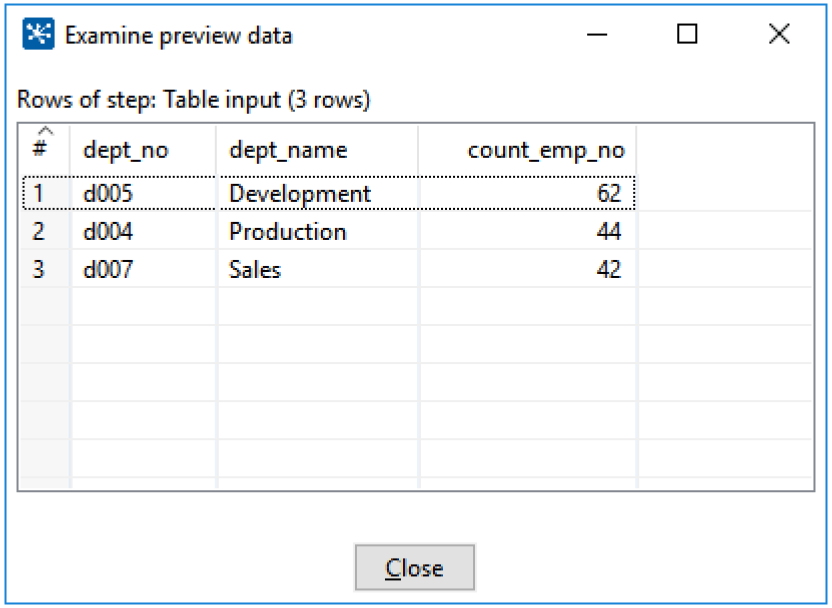
Execute for each row? ☐

Limit size: 0

Alternatives

- A completely different solution



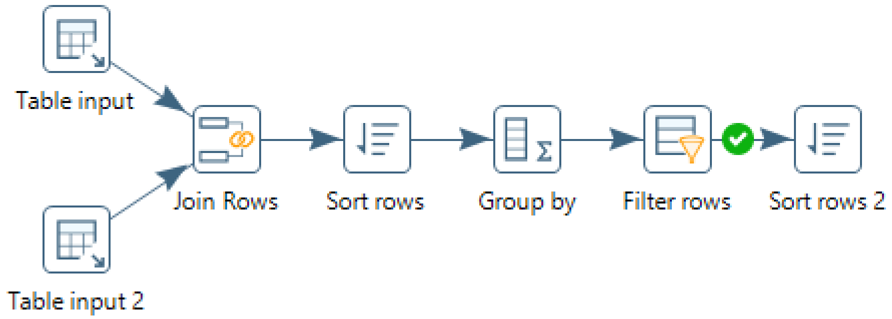


Rows of step: Table input (3 rows)

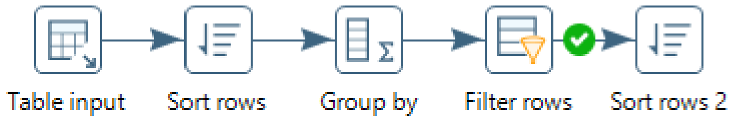
#	dept_no	dept_name	count_emp_no
1	d005	Development	62
2	d004	Production	44
3	d007	Sales	42

Alternatives

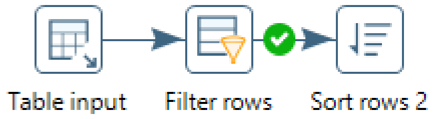
- Other possible intermediate solutions
  - column renaming in SQL



  - column renaming and table join in SQL



  - column renaming, table join, and group by in SQL



Alternatives

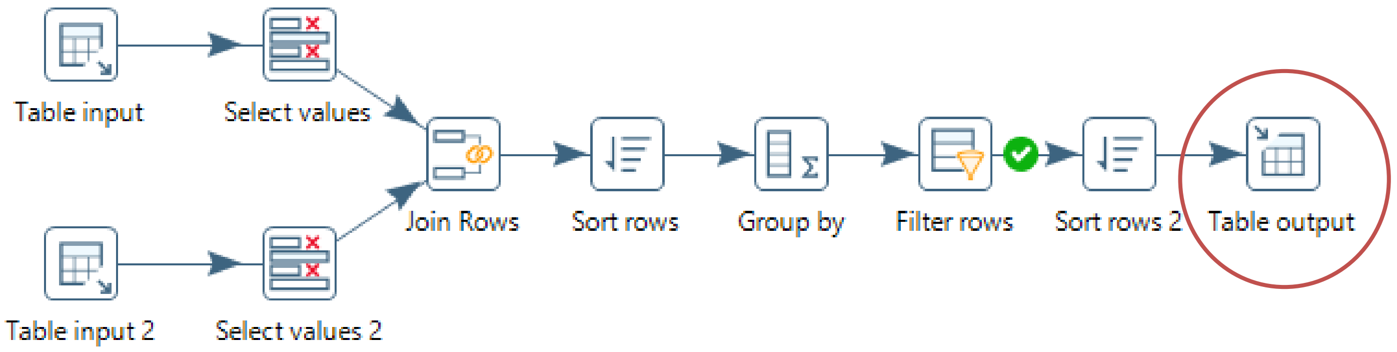
- As a general rule
  - offload as much as possible to database system
    - filtering rows, selecting columns, and (especially) table joins
  - unless the required data comes from multiple data sources
  - or when processing is difficult to implement in SQL
    - e.g. duplicate detection via string matching

ETL tools

- Then why use an ETL tool?
  - data comes from different databases/systems
  - data sources other than databases (e.g. text files)
  - complex data merging and transformations
  - approximate matching, duplicate detection, data cleaning
  - materialization to different outputs (databases, files, etc.)

Materialization

- Materialization to database table



Materialization

- Materialization to database table

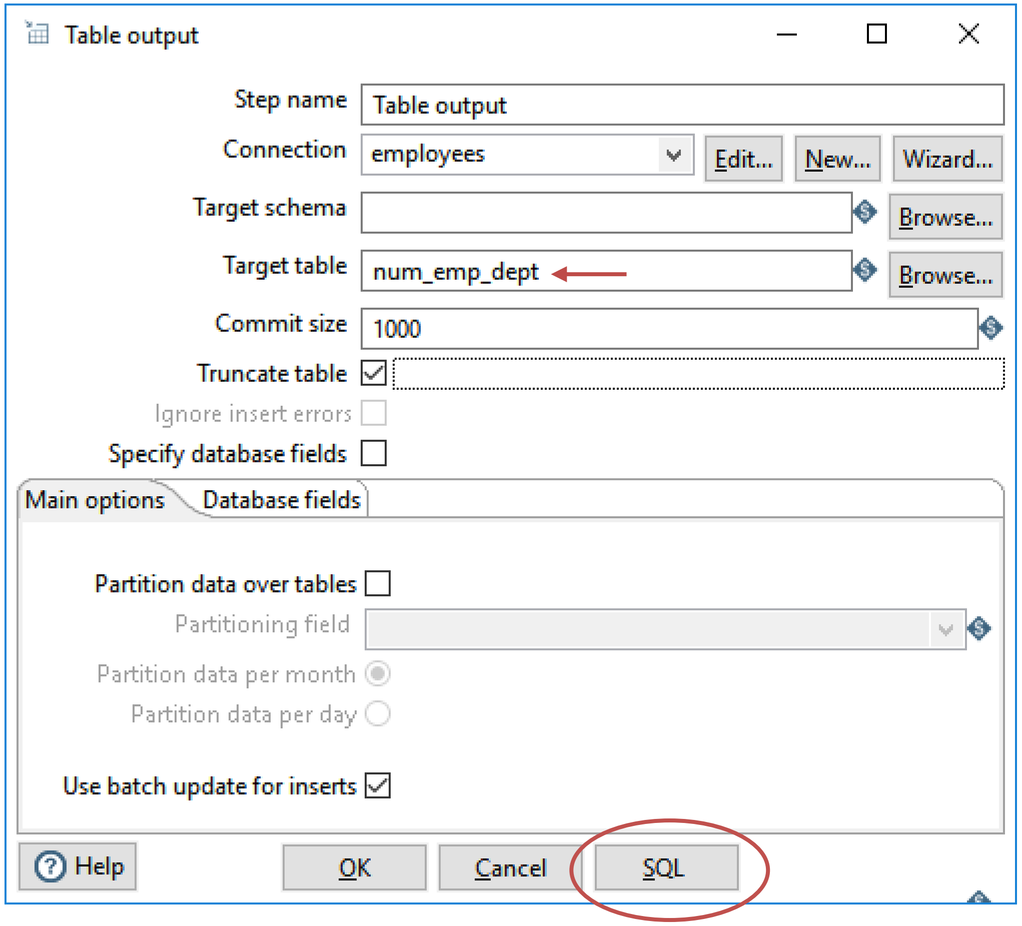


Table output

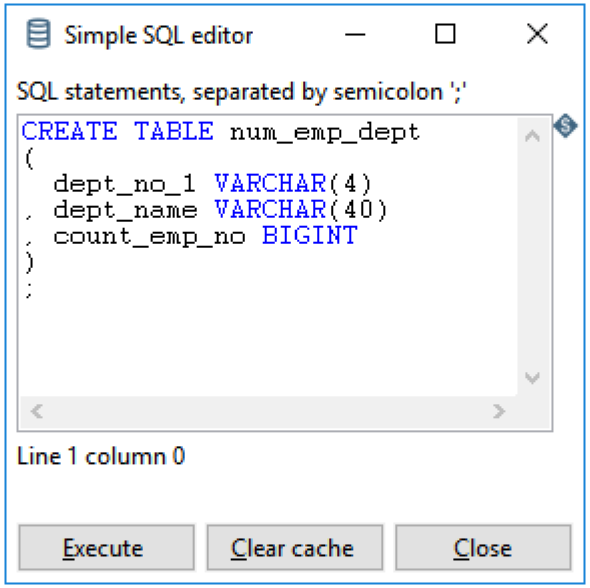
Step name	Table output
Connection	employees
Target schema	
Target table	num_emp_dept
Commit size	1000
Truncate table	✓
Ignore insert errors	
Specify database fields	

Main options | Database fields

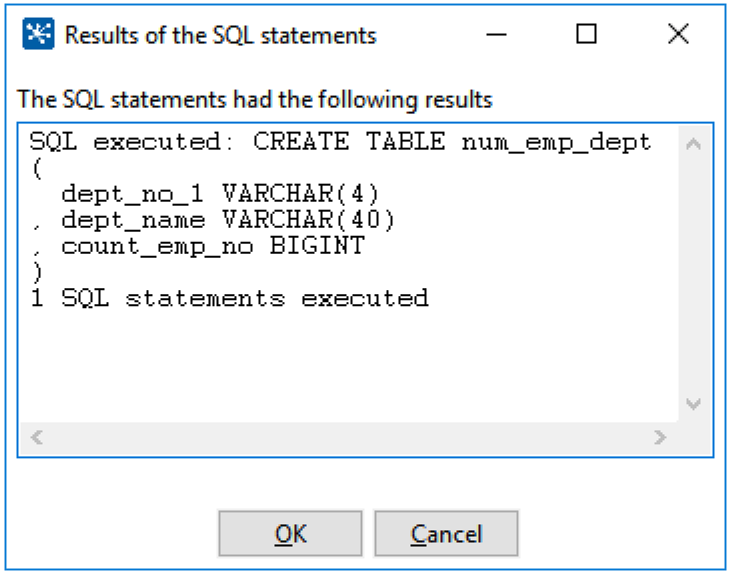
Partition data over tables	
Partitioning field	
Partition data per month	●
Partition data per day	
Use batch update for inserts	✓

Materialization

- Materialization to database table



```
CREATE TABLE num_emp_dept
(
  dept_no_1 VARCHAR(4)
, dept_name VARCHAR(40)
, count_emp_no BIGINT
)
;
```

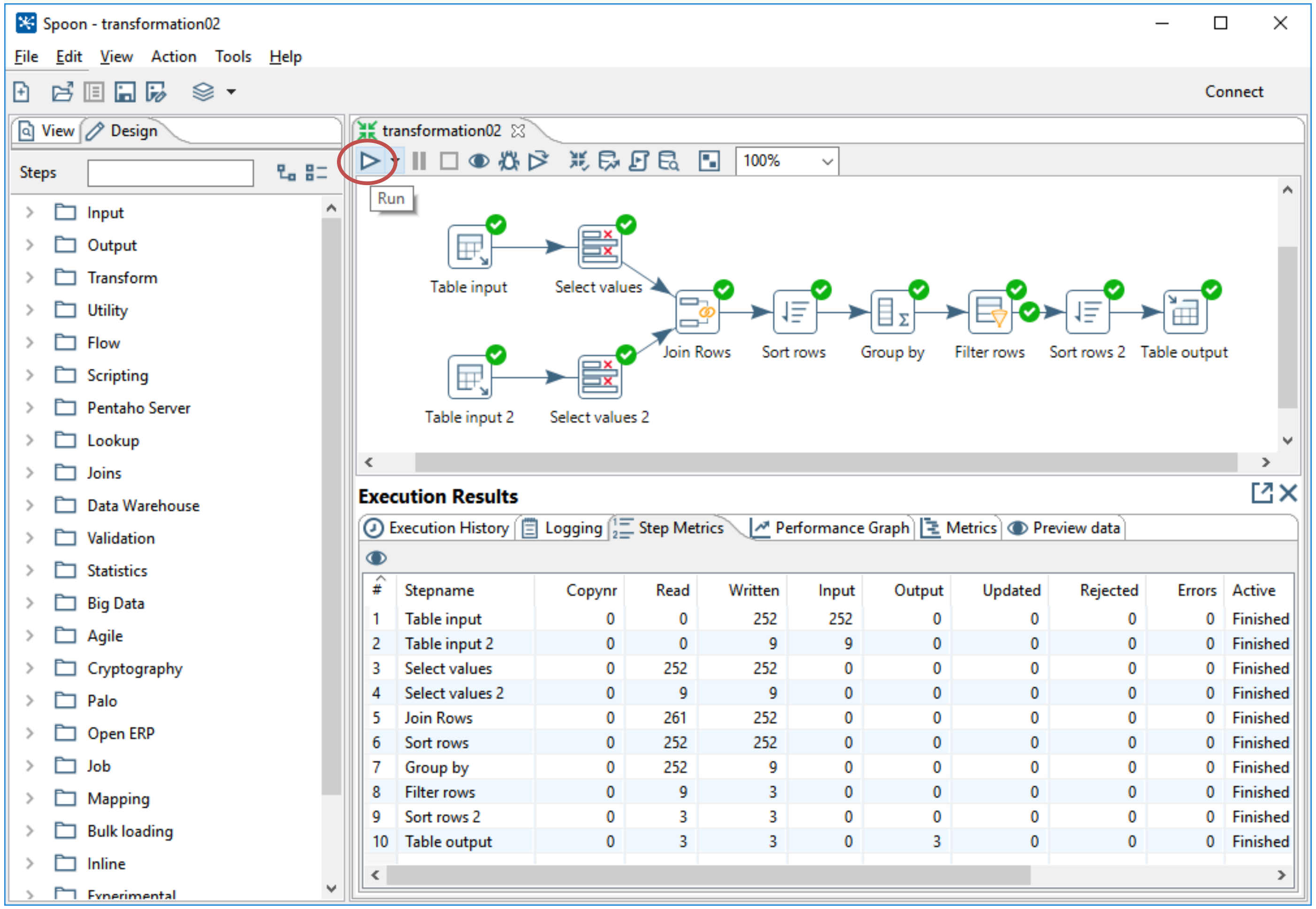


Results of the SQL statements
The SQL statements had the following results

```
SQL executed: CREATE TABLE num_emp_dept
(
  dept_no_1 VARCHAR(4)
, dept_name VARCHAR(40)
, count_emp_no BIGINT
)
1 SQL statements executed
```

Materialization

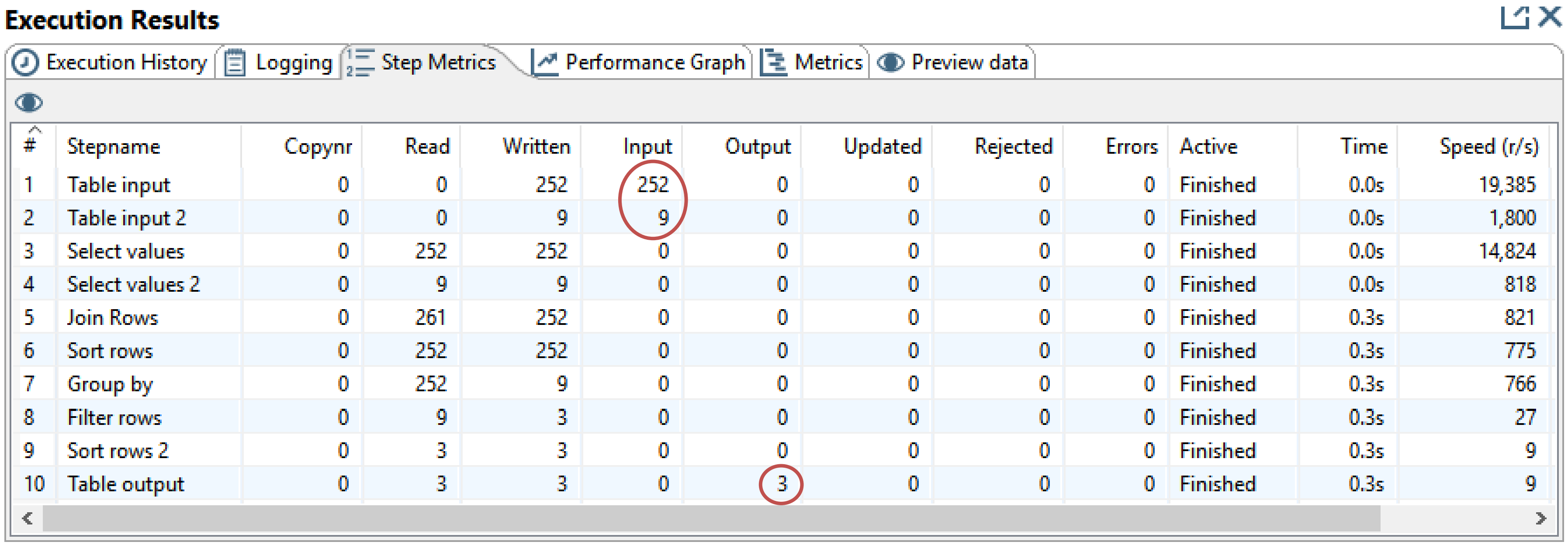
- Running the transformation



#	Stepname	Copynr	Read	Written	Input	Output	Updated	Rejected	Errors	Active
1	Table input	0	0	252	252	0	0	0	0	Finished
2	Table input 2	0	0	9	9	0	0	0	0	Finished
3	Select values	0	252	252	0	0	0	0	0	Finished
4	Select values 2	0	9	9	0	0	0	0	0	Finished
5	Join Rows	0	261	252	0	0	0	0	0	Finished
6	Sort rows	0	252	252	0	0	0	0	0	Finished
7	Group by	0	252	9	0	0	0	0	0	Finished
8	Filter rows	0	9	3	0	0	0	0	0	Finished
9	Sort rows 2	0	3	3	0	0	0	0	0	Finished
10	Table output	0	3	3	0	3	0	0	0	Finished

Materialization

- Running the transformation



#	Stepname	Copynr	Read	Written	Input	Output	Updated	Rejected	Errors	Active	Time	Speed (r/s)
1	Table input	0	0	252	252	0	0	0	0	Finished	0.0s	19,385
2	Table input 2	0	0	9	9	0	0	0	0	Finished	0.0s	1,800
3	Select values	0	252	252	0	0	0	0	0	Finished	0.0s	14,824
4	Select values 2	0	9	9	0	0	0	0	0	Finished	0.0s	818
5	Join Rows	0	261	252	0	0	0	0	0	Finished	0.3s	821
6	Sort rows	0	252	252	0	0	0	0	0	Finished	0.3s	775
7	Group by	0	252	9	0	0	0	0	0	Finished	0.3s	766
8	Filter rows	0	9	3	0	0	0	0	0	Finished	0.3s	27
9	Sort rows 2	0	3	3	0	0	0	0	0	Finished	0.3s	9
10	Table output	0	3	3	0	3	0	0	0	Finished	0.3s	9

Materialization

- Materialization to database table

select * **from** num_emp_dept;

```
+------------+-------------+--------------+
| dept_no_1  | dept_name   | count_emp_no |
+------------+-------------+--------------+
| d005       | Development |           62 |
| d004       | Production  |           44 |
| d007       | Sales       |           42 |
+------------+-------------+--------------+
3 rows in set (0.00 sec)
```