ASSIGNMENT 1

Tecnologias de Bases de Dados

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GROUP D

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Índice

Constraints Y

Defining primary key and foreign key constraints on MySQL tables can significantly improve query performance.

When a primary key is defined on a table, an index is automatically created on that column. This index enables the database engine to easily locate specific rows in the table, which can greatly reduce query execution time.

Similarly, when a foreign key is defined, it establishes a relationship between two tables that can be used to join them together efficiently.

By utilizing these constraints, the database engine can avoid expensive table scans and instead use indexes to quickly retrieve the necessary data and enhance some queries performance.

```
ALTER TABLE ydocentes ADD CONSTRAINT ydocentes_pk PRIMARY KEY (nr);
ALTER TABLE zdocentes ADD CONSTRAINT zdocentes_pk PRIMARY KEY (nr);

ALTER TABLE yucs ADD CONSTRAINT yucs_pk PRIMARY KEY (codigo);
ALTER TABLE zucs ADD CONSTRAINT zucs_pk PRIMARY KEY (codigo);

ALTER TABLE yocorrencias ADD CONSTRAINT yocorrencias_pk PRIMARY KEY (codigo,
ano_letivo, periodo);
ALTER TABLE yocorrencias ADD CONSTRAINT yocorrencias_fk FOREIGN KEY(codigo)
REFERENCES yucs(codigo);
ALTER TABLE zocorrencias ADD CONSTRAINT zocorrencias_pk PRIMARY KEY (codigo,
ano_letivo, periodo);
ALTER TABLE zocorrencias ADD CONSTRAINT zocorrencias_fk FOREIGN KEY(codigo)
REFERENCES zucs(codigo);

ALTER TABLE ytiposaula ADD CONSTRAINT ytiposaula_pk PRIMARY KEY(id);
ALTER TABLE ytiposaula ADD CONSTRAINT ytiposaula_fk FOREIGN KEY (ano_letivo,
periodo, codigo) REFERENCES yocorrencias(ano_letivo, periodo, codigo);
ALTER TABLE ztiposaula ADD CONSTRAINT ztiposaula_pk PRIMARY KEY(id);
ALTER TABLE ztiposaula ADD CONSTRAINT ztiposaula_fk FOREIGN KEY (ano_letivo,
periodo, codigo) REFERENCES zocorrencias(ano_letivo, periodo, codigo);

ALTER TABLE ydsd ADD CONSTRAINT ydsd_pk PRIMARY KEY (nr,id);
ALTER TABLE ydsd ADD CONSTRAINT ydsd_fk1 FOREIGN KEY (nr) REFERENCES
ydocentes(nr);
ALTER TABLE ydsd ADD CONSTRAINT ydsd_fk2 FOREIGN KEY (id) REFERENCES
ytiposaula(id);
ALTER TABLE zdsd ADD CONSTRAINT zdsd_pk PRIMARY KEY (nr,id);
ALTER TABLE zdsd ADD CONSTRAINT zdsd_fk1 FOREIGN KEY (nr) REFERENCES
zdocentes(nr);
ALTER TABLE zdsd ADD CONSTRAINT zdsd_fk2 FOREIGN KEY (id) REFERENCES
ztiposaula(id);
```

Constraints Z

Overall, we consider indexing columns that are frequently used in the WHERE clause of our queries. By indexing these columns, we can improve the performance of queries that filter rows based on those columns.

We chose to index **curso** and **designacao** on the table **zucs**, **curso** on the table **zucs**, **ano_letivo** on the table **zocorrencias** and **ano_letivo** on the table **ztiposaula**.

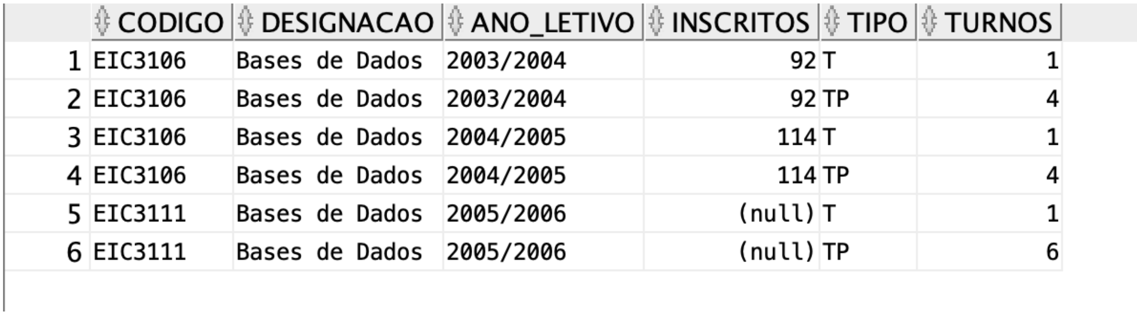
```
CREATE INDEX ucs_idx ON zucs (curso, designacao);
CREATE INDEX ucs_idx_curso ON zucs (curso);
CREATE INDEX ocorrencias_idx ON zocorrencias (ano_letivo);
CREATE INDEX tiposaula_idx_anoletivo ON ztiposaula (ano_letivo);
```

Query 1 - Show the codigo, designacao, ano_letivo, inscritos, tipo, and turnos for the course ‘Bases de Dados’ of the program 275.

1) the SQL query;

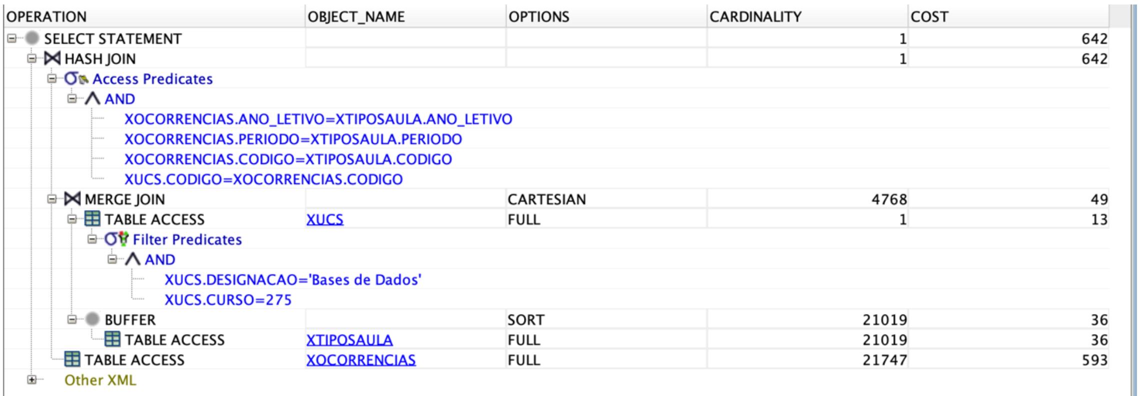
```
SELECT xucs.codigo, xucs.designacao, xocorrencias.ano_letivo,
xocorrencias.inscritos,xtiposaula.tipo,xtiposaula.turnos
FROM xucs
JOIN xocorrencias ON xucs.codigo=xocorrencias.codigo
JOIN xtiposaula ON xocorrencias.ano_letivo=xtiposaula.ano_letivo
AND xocorrencias.periodo= xtiposaula.periodo
AND xocorrencias.codigo=xtiposaula.codigo
WHERE curso='275' AND designacao='Bases de Dados';
```

2) the answer;

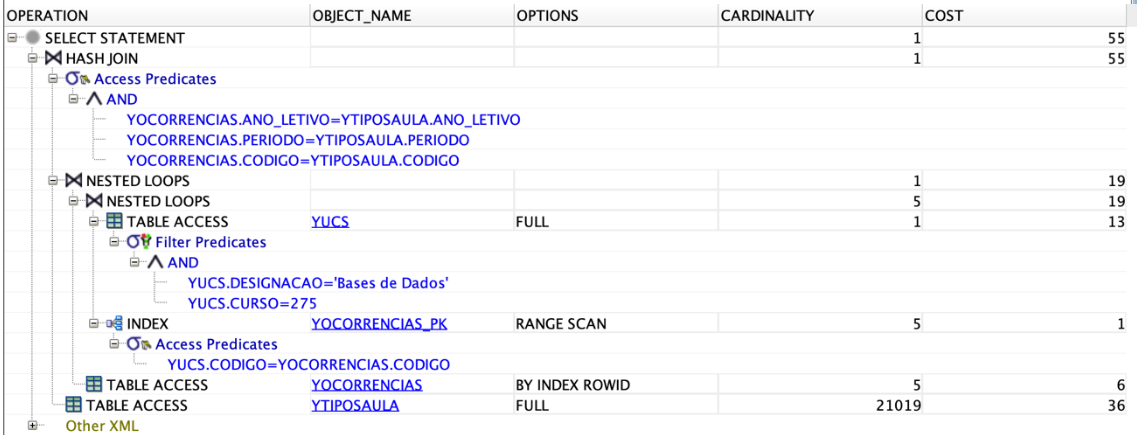


	CODIGO	DESIGNACAO	ANO_LETIVO	INSCRITOS	TIPO	TURNOS
1	EIC3106	Bases de Dados	2003/2004	92	T	1
2	EIC3106	Bases de Dados	2003/2004	92	TP	4
3	EIC3106	Bases de Dados	2004/2005	114	T	1
4	EIC3106	Bases de Dados	2004/2005	114	TP	4
5	EIC3111	Bases de Dados	2005/2006	(null)	T	1
6	EIC3111	Bases de Dados	2005/2006	(null)	TP	6

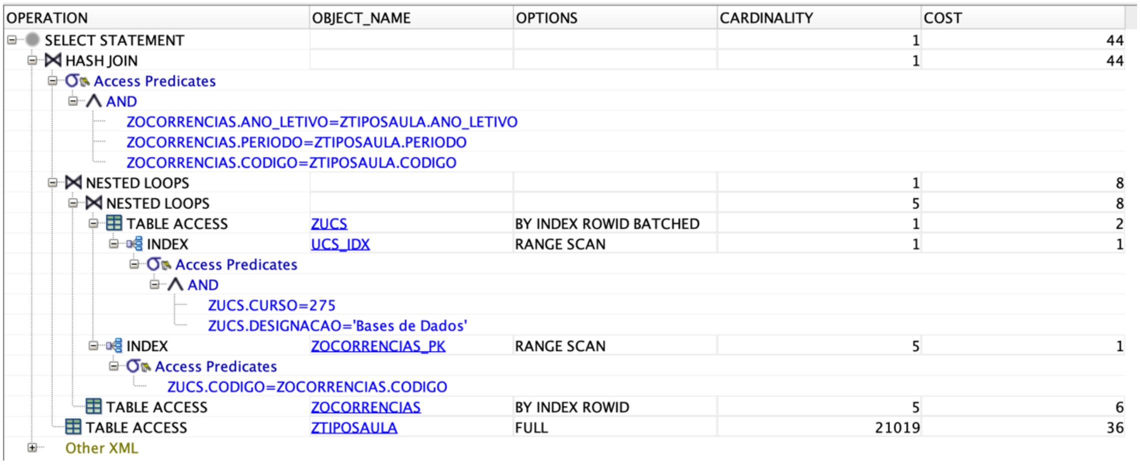
3) the three execution plans in the three environments, their analysis and of the corresponding estimated effort



```
OPERATION                                     OBJECT_NAME     OPTIONS      CARDINALITY   COST
SELECT STATEMENT                                                                     1    642
  HASH JOIN                                                                          1    642
    Access Predicates
      AND
        XOCORRENCIAS.ANO_LETIVO=XTIPOSAULA.ANO_LETIVO
        XOCORRENCIAS.PERIODO=XTIPOSAULA.PERIODO
        XOCORRENCIAS.CODIGO=XTIPOSAULA.CODIGO
        XUCS.CODIGO=XOCORRENCIAS.CODIGO
    MERGE JOIN                                                CARTESIAN           4768     49
      TABLE ACCESS                            XUCS            FULL                   1     13
        Filter Predicates
          AND
            XUCS.DESIGNACAO='Bases de Dados'
            XUCS.CURSO=275
      BUFFER                                                  SORT               21019     36
        TABLE ACCESS                          XTIPOSAULA      FULL               21019     36
    TABLE ACCESS                              XOCORRENCIAS    FULL               21747    593
  Other XML
```



```
OPERATION                                     OBJECT_NAME       OPTIONS         CARDINALITY   COST
SELECT STATEMENT                                                                          1     55
  HASH JOIN                                                                               1     55
    Access Predicates
      AND
        YOCORRENCIAS.ANO_LETIVO=YTIPOSAULA.ANO_LETIVO
        YOCORRENCIAS.PERIODO=YTIPOSAULA.PERIODO
        YOCORRENCIAS.CODIGO=YTIPOSAULA.CODIGO
    NESTED LOOPS                                                                          1     19
      NESTED LOOPS                                                                        5     19
        TABLE ACCESS                          YUCS              FULL                      1     13
          Filter Predicates
            AND
              YUCS.DESIGNACAO='Bases de Dados'
              YUCS.CURSO=275
        INDEX                                 YOCORRENCIAS_PK   RANGE SCAN                5      1
          Access Predicates
            YUCS.CODIGO=YOCORRENCIAS.CODIGO
      TABLE ACCESS                            YOCORRENCIAS      BY INDEX ROWID            5      6
    TABLE ACCESS                              YTIPOSAULA        FULL                  21019     36
  Other XML
```



OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY	COST
SELECT STATEMENT			1	44
HASH JOIN			1	44
Access Predicates				
AND				
ZOCORRENCIAS.ANO_LETIVO=ZTIPOSAULA.ANO_LETIVO				
ZOCORRENCIAS.PERIODO=ZTIPOSAULA.PERIODO				
ZOCORRENCIAS.CODIGO=ZTIPOSAULA.CODIGO				
NESTED LOOPS			1	8
NESTED LOOPS			5	8
TABLE ACCESS	ZUCS	BY INDEX ROWID BATCHED	1	2
INDEX	UCS_IDX	RANGE SCAN	1	1
Access Predicates				
AND				
ZUCS.CURSO=275				
ZUCS.DESIGNACAO='Bases de Dados'				
INDEX	ZOCORRENCIAS_PK	RANGE SCAN	5	1
Access Predicates				
ZUCS.CODIGO=ZOCORRENCIAS.CODIGO				
TABLE ACCESS	ZOCORRENCIAS	BY INDEX ROWID	5	6
TABLE ACCESS	ZTIPOSAULA	FULL	21019	36
Other XML				

The usage of the foreign keys codigo and ano_letivo improved the cost of the JOIN between yocorrencias and yucs and the JOIN between yocorrencias and ytiposaula.

The usage of the index ucs_index improved the cost of filtering the curso and designacao in environment z.

4) if the execution time is measurable, a comparison of the execution times in the three environments.

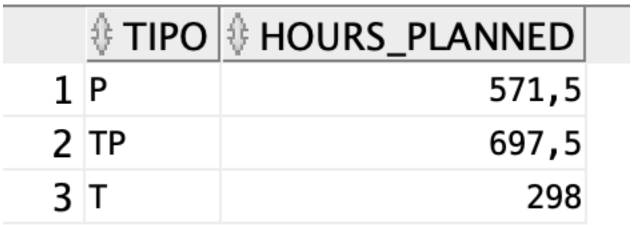
Environment	Execution Time (ms)
Environment X	78
Environment Y	37
Environment Z	34

Query 2 - How many class hours of each type did the program 233 planned in year 2004/2005?

1) the SQL query;

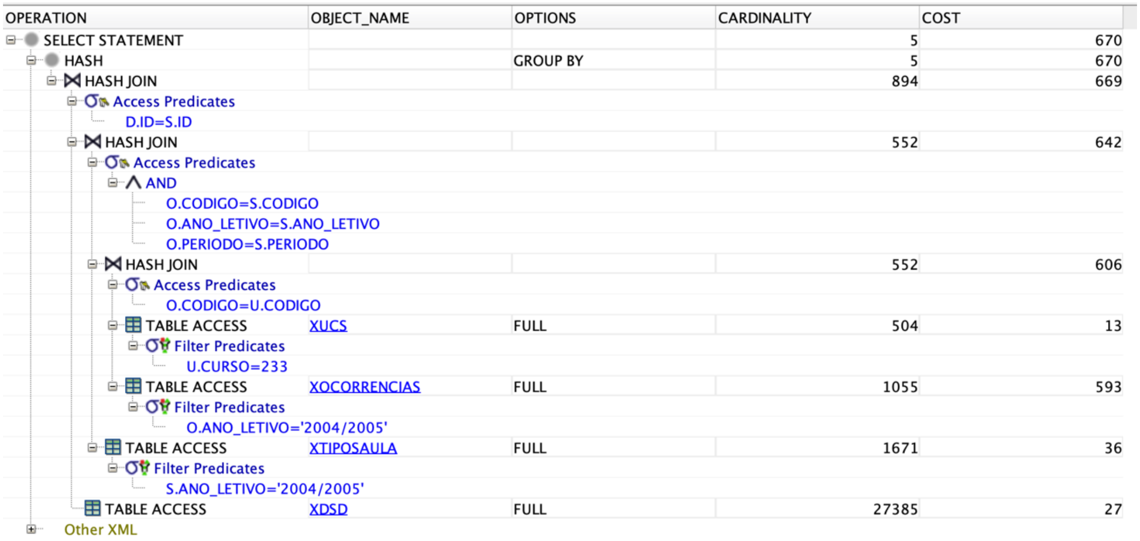
```
SELECT tipo, SUM(horas) as hours_planned
FROM xtiposaula s JOIN xdsd d  ON d.id=s.id
JOIN xocorrencias o ON o.codigo=s.codigo AND o.ano_letivo=s.ano_letivo AND
o.periodo=s.periodo
JOIN xucs u ON o.codigo=u.codigo
WHERE u.curso=233 AND o.ano_letivo='2004/2005'
GROUP BY s.tipo;
```

2) the answer;

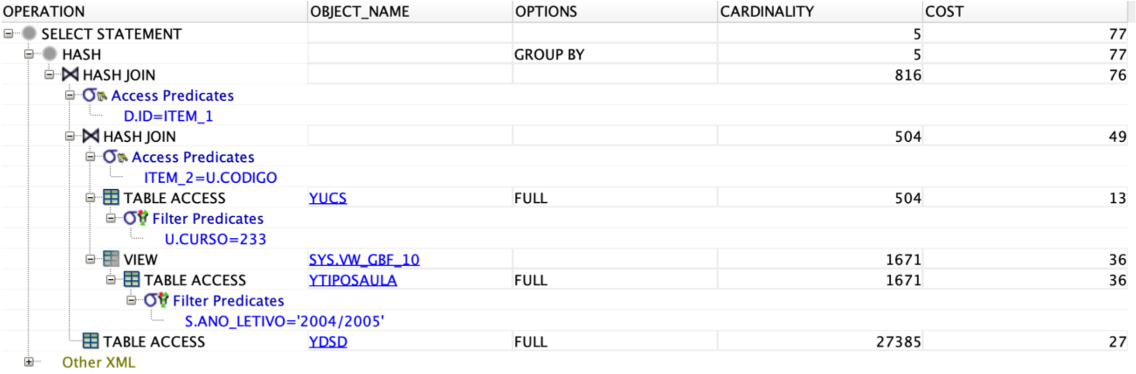


	TIPO	HOURS_PLANNED
1	P	571,5
2	TP	697,5
3	T	298

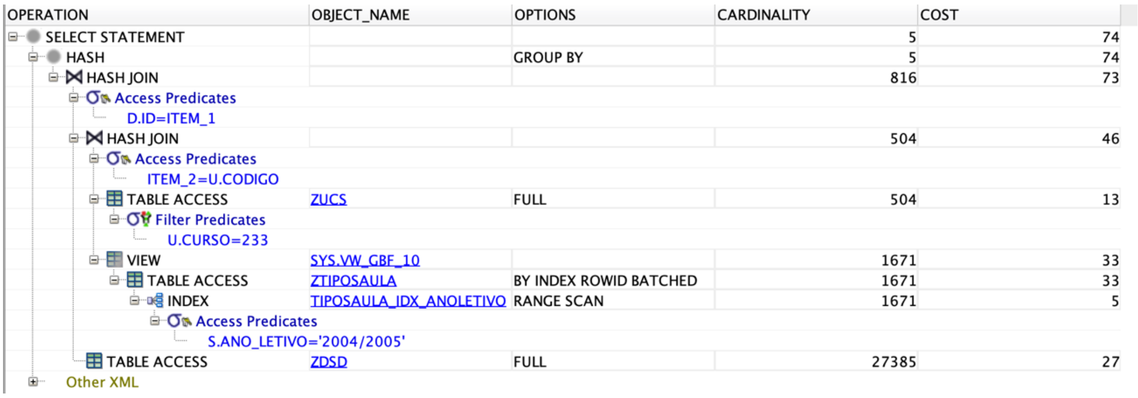
3) the three execution plans in the three environments, their analysis and of the corresponding estimated effort;



```
OPERATION                              OBJECT_NAME     OPTIONS    CARDINALITY   COST
SELECT STATEMENT                                                            5    670
  HASH                                                 GROUP BY             5    670
    HASH JOIN                                                             894    669
      Access Predicates
        D.ID=S.ID
      HASH JOIN                                                           552    642
        Access Predicates
          AND
            O.CODIGO=S.CODIGO
            O.ANO_LETIVO=S.ANO_LETIVO
            O.PERIODO=S.PERIODO
        HASH JOIN                                                         552    606
          Access Predicates
            O.CODIGO=U.CODIGO
          TABLE ACCESS                 XUCS            FULL               504     13
            Filter Predicates
              U.CURSO=233
          TABLE ACCESS                 XOCORRENCIAS    FULL              1055    593
            Filter Predicates
              O.ANO_LETIVO='2004/2005'
        TABLE ACCESS                   XTIPOSAULA      FULL              1671     36
          Filter Predicates
            S.ANO_LETIVO='2004/2005'
      TABLE ACCESS                     XDSD            FULL             27385     27
  Other XML
```



OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY	COST
SELECT STATEMENT			5	77
HASH		GROUP BY	5	77
HASH JOIN			816	76
Access Predicates				
D.ID=ITEM_1				
HASH JOIN			504	49
Access Predicates				
ITEM_2=U.CODIGO				
TABLE ACCESS	YUCS	FULL	504	13
Filter Predicates				
U.CURSO=233				
VIEW	SYS.VW_GBF_10		1671	36
TABLE ACCESS	YTIPOSAULA	FULL	1671	36
Filter Predicates				
S.ANO_LETIVO='2004/2005'				
TABLE ACCESS	YDSD	FULL	27385	27
Other XML				



OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY	COST
SELECT STATEMENT			5	74
HASH		GROUP BY	5	74
HASH JOIN			816	73
Access Predicates				
D.ID=ITEM_1				
HASH JOIN			504	46
Access Predicates				
ITEM_2=U.CODIGO				
TABLE ACCESS	ZUCS	FULL	504	13
Filter Predicates				
U.CURSO=233				
VIEW	SYS.VW_GBF_10		1671	33
TABLE ACCESS	ZTIPOSAULA	BY INDEX ROWID BATCHED	1671	33
INDEX	TIPOSAULA_IDX_ANOLETIVO	RANGE SCAN	1671	5
Access Predicates				
S.ANO_LETIVO='2004/2005'				
TABLE ACCESS	ZDSD	FULL	27385	27
Other XML				

The usage of the foreign keys codigo, ano_letivo and period improved the cost of the JOIN between yocorrencias and ytiposaula.

The usage of the index tiposaula_idx_anoletivo improved the cost of filtering the ano_letivo in environment z.

4) if the execution time is measurable, a comparison of the execution times in the three environments.

Environment	Execution Time (ms)
Environment X	41
Environment Y	30
Environment Z	27

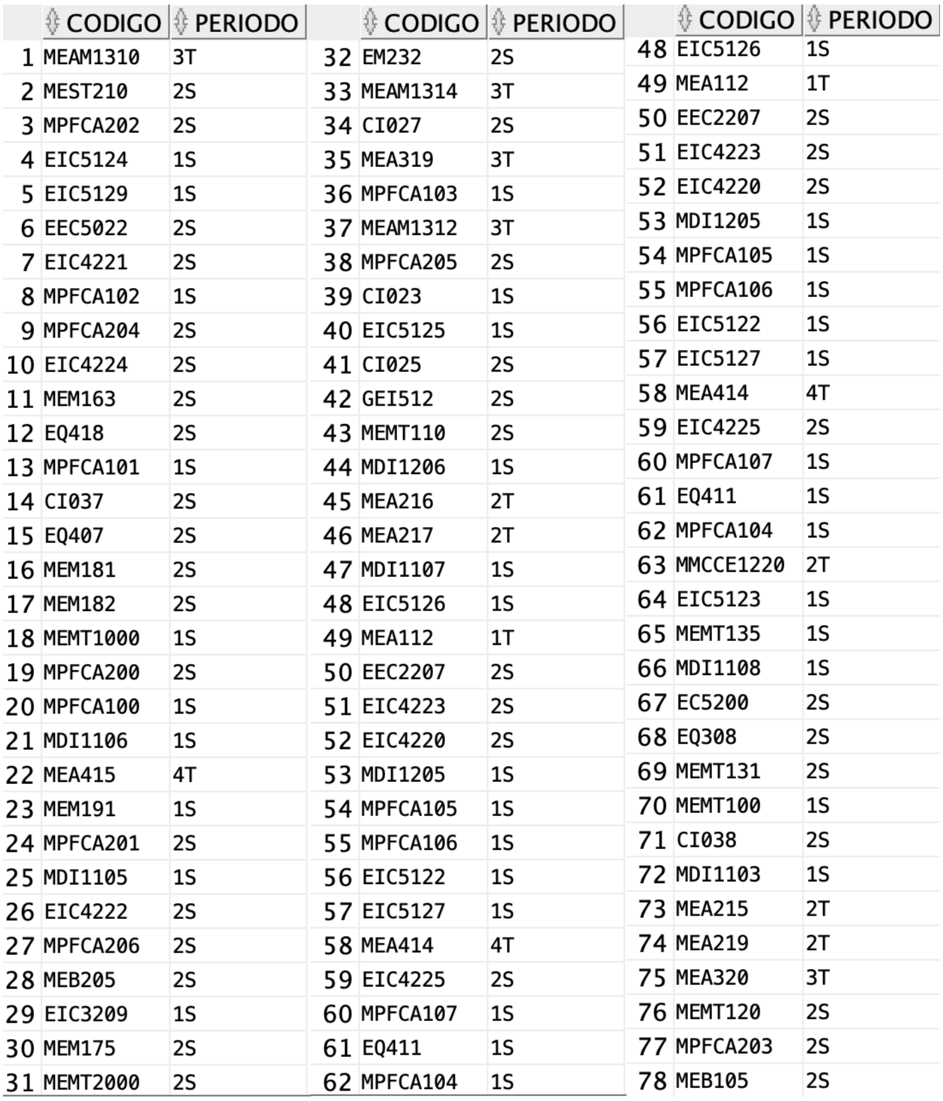
Query 3 - Which courses (show the code) did have occurrences planned but did not get service assigned in year 2003/2004?

a. Use not in.

1) the SQL query;

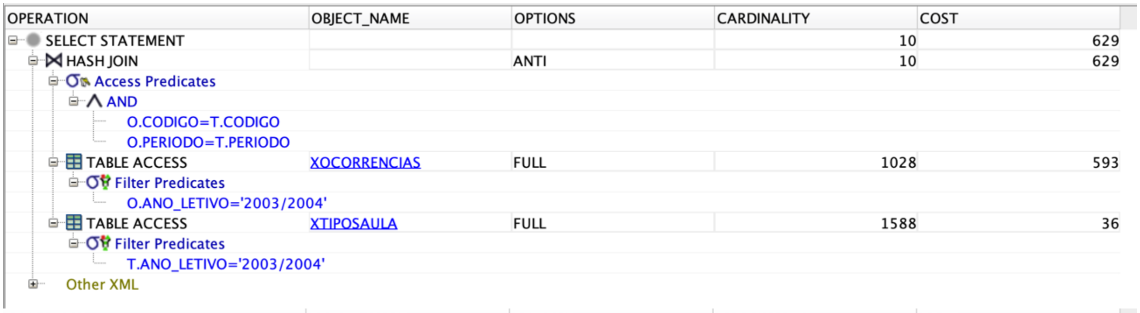
```
SELECT o.codigo, o.periodo
FROM xocorrencias o
WHERE o.ano_letivo='2003/2004'
AND (o.codigo, o.periodo) NOT IN
(SELECT t.codigo, t.periodo FROM xtiposaula t WHERE
t.ano_letivo='2003/2004');
```

2) the answer;

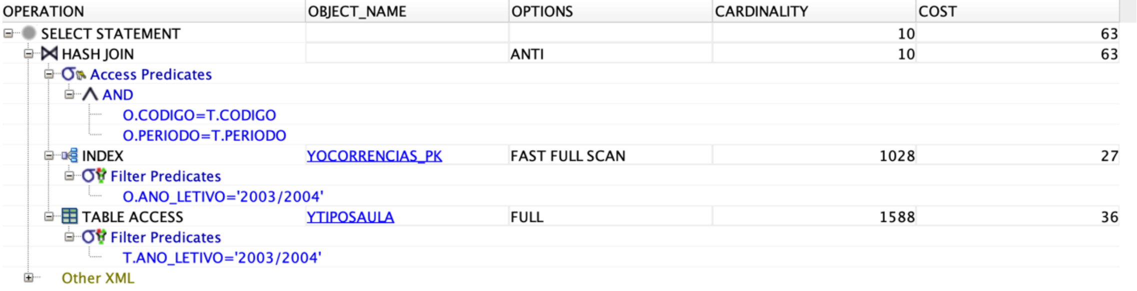


	CODIGO	PERIODO
1	MEAM1310	3T
2	MEST210	2S
3	MPFCA202	2S
4	EIC5124	1S
5	EIC5129	1S
6	EEC5022	2S
7	EIC4221	2S
8	MPFCA102	1S
9	MPFCA204	2S
10	EIC4224	2S
11	MEM163	2S
12	EQ418	2S
13	MPFCA101	1S
14	CI037	2S
15	EQ407	2S
16	MEM181	2S
17	MEM182	2S
18	MEMT1000	1S
19	MPFCA200	2S
20	MPFCA100	1S
21	MDI1106	1S
22	MEA415	4T
23	MEM191	1S
24	MPFCA201	2S
25	MDI1105	1S
26	EIC4222	2S
27	MPFCA206	2S
28	MEB205	2S
29	EIC3209	1S
30	MEM175	2S
31	MEMT2000	2S
32	EM232	2S
33	MEAM1314	3T
34	CI027	2S
35	MEA319	3T
36	MPFCA103	1S
37	MEAM1312	3T
38	MPFCA205	2S
39	CI023	1S
40	EIC5125	1S
41	CI025	2S
42	GEI512	2S
43	MEMT110	2S
44	MDI1206	1S
45	MEA216	2T
46	MEA217	2T
47	MDI1107	1S
48	EIC5126	1S
49	MEA112	1T
50	EEC2207	2S
51	EIC4223	2S
52	EIC4220	2S
53	MDI1205	1S
54	MPFCA105	1S
55	MPFCA106	1S
56	EIC5122	1S
57	EIC5127	1S
58	MEA414	4T
59	EIC4225	2S
60	MPFCA107	1S
61	EQ411	1S
62	MPFCA104	1S
48	EIC5126	1S
49	MEA112	1T
50	EEC2207	2S
51	EIC4223	2S
52	EIC4220	2S
53	MDI1205	1S
54	MPFCA105	1S
55	MPFCA106	1S
56	EIC5122	1S
57	EIC5127	1S
58	MEA414	4T
59	EIC4225	2S
60	MPFCA107	1S
61	EQ411	1S
62	MPFCA104	1S
63	MMCCE1220	2T
64	EIC5123	1S
65	MEMT135	1S
66	MDI1108	1S
67	EC5200	2S
68	EQ308	2S
69	MEMT131	2S
70	MEMT100	1S
71	CI038	2S
72	MDI1103	1S
73	MEA215	2T
74	MEA219	2T
75	MEA320	3T
76	MEMT120	2S
77	MPFCA203	2S
78	MEB105	2S

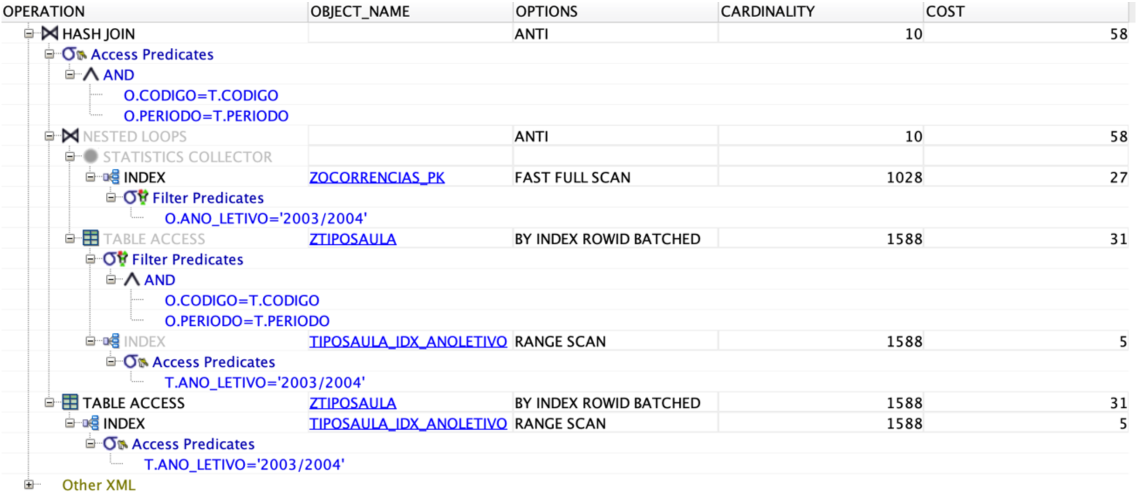
3) the three execution plans in the three environments, their analysis and of the corresponding estimated effort;



```
OPERATION                    OBJECT_NAME        OPTIONS            CARDINALITY    COST
SELECT STATEMENT                                                            10     629
  HASH JOIN                                     ANTI                        10     629
    Access Predicates
      AND
        O.CODIGO=T.CODIGO
        O.PERIODO=T.PERIODO
    TABLE ACCESS             XOCORRENCIAS       FULL                      1028     593
      Filter Predicates
        O.ANO_LETIVO='2003/2004'
    TABLE ACCESS             XTIPOSAULA         FULL                      1588      36
      Filter Predicates
        T.ANO_LETIVO='2003/2004'
  Other XML
```



```
OPERATION                    OBJECT_NAME        OPTIONS            CARDINALITY    COST
SELECT STATEMENT                                                            10      63
  HASH JOIN                                     ANTI                        10      63
    Access Predicates
      AND
        O.CODIGO=T.CODIGO
        O.PERIODO=T.PERIODO
    INDEX                    YOCORRENCIAS_PK    FAST FULL SCAN            1028      27
      Filter Predicates
        O.ANO_LETIVO='2003/2004'
    TABLE ACCESS             YTIPOSAULA         FULL                      1588      36
      Filter Predicates
        T.ANO_LETIVO='2003/2004'
  Other XML
```



```
OPERATION                    OBJECT_NAME               OPTIONS                 CARDINALITY    COST
  HASH JOIN                                            ANTI                             10      58
    Access Predicates
      AND
        O.CODIGO=T.CODIGO
        O.PERIODO=T.PERIODO
    NESTED LOOPS                                       ANTI                             10      58
      STATISTICS COLLECTOR
        INDEX                ZOCORRENCIAS_PK           FAST FULL SCAN                 1028      27
          Filter Predicates
            O.ANO_LETIVO='2003/2004'
      TABLE ACCESS           ZTIPOSAULA                BY INDEX ROWID BATCHED         1588      31
        Filter Predicates
          AND
            O.CODIGO=T.CODIGO
            O.PERIODO=T.PERIODO
        INDEX                TIPOSAULA_IDX_ANOLETIVO   RANGE SCAN                     1588       5
          Access Predicates
            T.ANO_LETIVO='2003/2004'
    TABLE ACCESS             ZTIPOSAULA                BY INDEX ROWID BATCHED         1588      31
      INDEX                  TIPOSAULA_IDX_ANOLETIVO   RANGE SCAN                     1588       5
        Access Predicates
          T.ANO_LETIVO='2003/2004'
  Other XML
```

The usage of the primary keys codigo and periodo improved the cost.

The usage of the index tiposaula_idx_anoletivo improved the cost of filtering the ano_letivo in environment z.

4) if the execution time is measurable, a comparison of the execution times in the three environments.

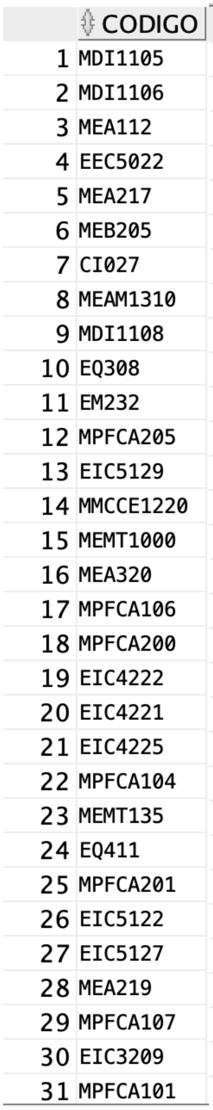
Environment	Execution Time (ms)
Environment X	516
Environment Y	172
Environment Z	115

b. Use external join and is null

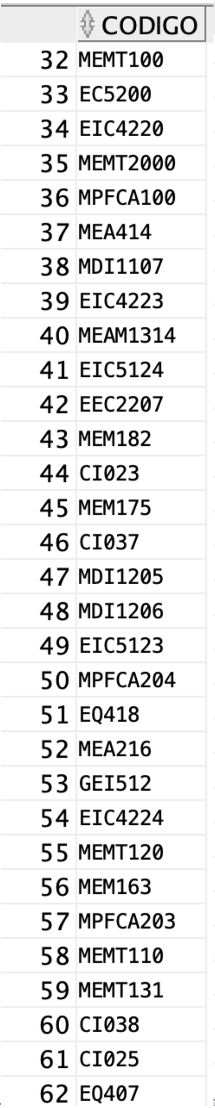
1) the SQL query;

```
SELECT o.codigo
FROM xocorrencias o
FULL OUTER JOIN xtiposaula t ON o.ano_letivo=t.ano_letivo AND o.periodo=
t.periodo AND o.codigo=t.codigo
WHERE o.ano_letivo='2003/2004'
AND t.id IS NULL;
```

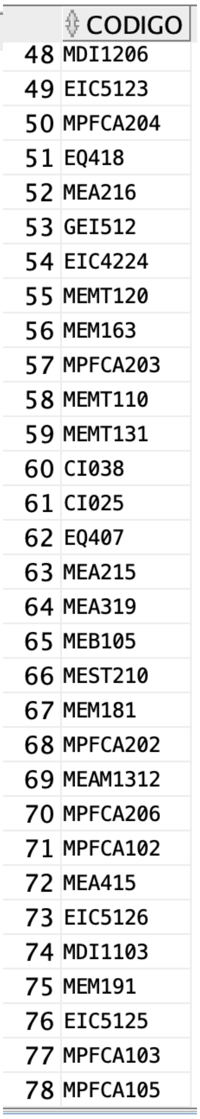
2) the answer;



	CODIGO
1	MDI1105
2	MDI1106
3	MEA112
4	EEC5022
5	MEA217
6	MEB205
7	CI027
8	MEAM1310
9	MDI1108
10	EQ308
11	EM232
12	MPFCA205
13	EIC5129
14	MMCCE1220
15	MEMT1000
16	MEA320
17	MPFCA106
18	MPFCA200
19	EIC4222
20	EIC4221
21	EIC4225
22	MPFCA104
23	MEMT135
24	EQ411
25	MPFCA201
26	EIC5122
27	EIC5127
28	MEA219
29	MPFCA107
30	EIC3209
31	MPFCA101

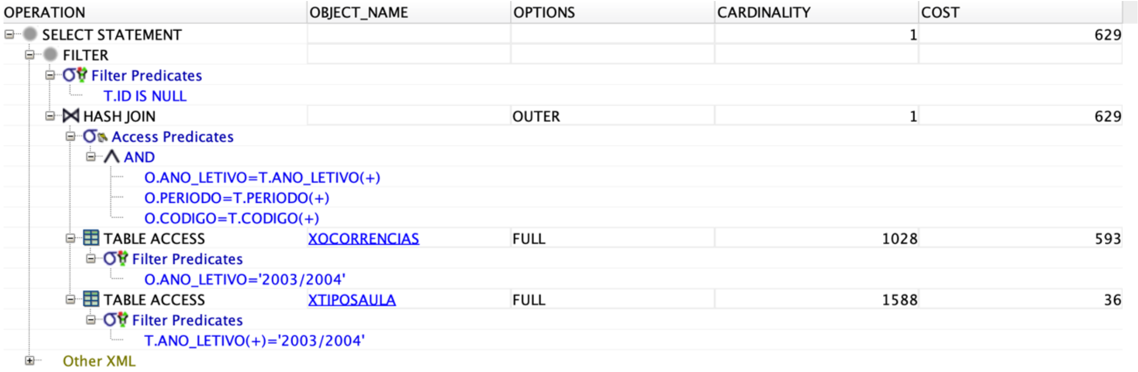


	CODIGO
32	MEMT100
33	EC5200
34	EIC4220
35	MEMT2000
36	MPFCA100
37	MEA414
38	MDI1107
39	EIC4223
40	MEAM1314
41	EIC5124
42	EEC2207
43	MEM182
44	CI023
45	MEM175
46	CI037
47	MDI1205
48	MDI1206
49	EIC5123
50	MPFCA204
51	EQ418
52	MEA216
53	GEI512
54	EIC4224
55	MEMT120
56	MEM163
57	MPFCA203
58	MEMT110
59	MEMT131
60	CI038
61	CI025
62	EQ407

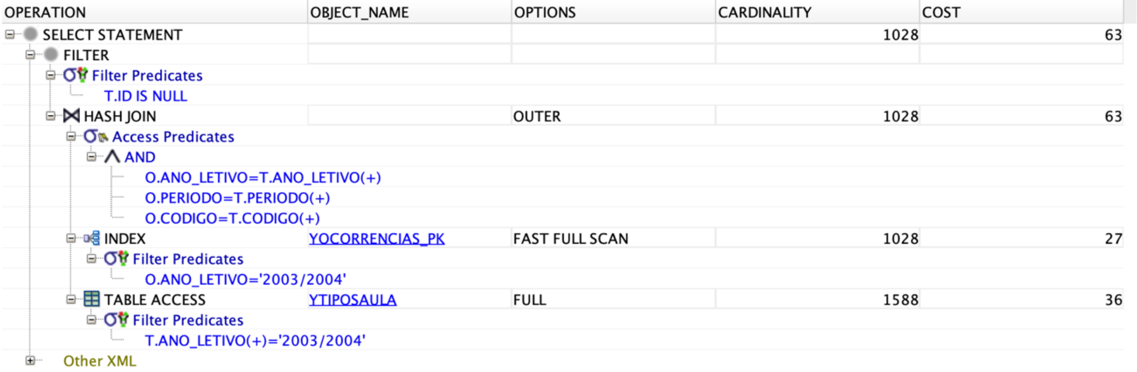


	CODIGO
48	MDI1206
49	EIC5123
50	MPFCA204
51	EQ418
52	MEA216
53	GEI512
54	EIC4224
55	MEMT120
56	MEM163
57	MPFCA203
58	MEMT110
59	MEMT131
60	CI038
61	CI025
62	EQ407
63	MEA215
64	MEA319
65	MEB105
66	MEST210
67	MEM181
68	MPFCA202
69	MEAM1312
70	MPFCA206
71	MPFCA102
72	MEA415
73	EIC5126
74	MDI1103
75	MEM191
76	EIC5125
77	MPFCA103
78	MPFCA105

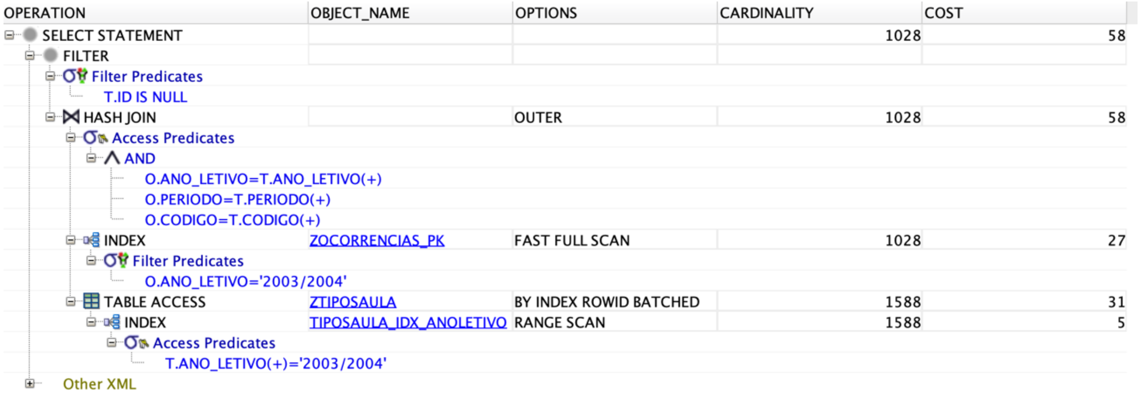
3) the three execution plans in the three environments, their analysis and of the corresponding estimated effort;



```
OPERATION                             OBJECT_NAME        OPTIONS          CARDINALITY     COST
SELECT STATEMENT                                                                    1      629
  FILTER
    Filter Predicates
      T.ID IS NULL
    HASH JOIN                                            OUTER                      1      629
      Access Predicates
        AND
          O.ANO_LETIVO=T.ANO_LETIVO(+)
          O.PERIODO=T.PERIODO(+)
          O.CODIGO=T.CODIGO(+)
      TABLE ACCESS                    XOCORRENCIAS       FULL                    1028      593
        Filter Predicates
          O.ANO_LETIVO='2003/2004'
      TABLE ACCESS                    XTIPOSAULA         FULL                    1588       36
        Filter Predicates
          T.ANO_LETIVO(+)='2003/2004'
  Other XML
```



```
OPERATION                             OBJECT_NAME        OPTIONS          CARDINALITY     COST
SELECT STATEMENT                                                                 1028       63
  FILTER
    Filter Predicates
      T.ID IS NULL
    HASH JOIN                                            OUTER                   1028       63
      Access Predicates
        AND
          O.ANO_LETIVO=T.ANO_LETIVO(+)
          O.PERIODO=T.PERIODO(+)
          O.CODIGO=T.CODIGO(+)
      INDEX                           YOCORRENCIAS_PK    FAST FULL SCAN          1028       27
        Filter Predicates
          O.ANO_LETIVO='2003/2004'
      TABLE ACCESS                    YTIPOSAULA         FULL                    1588       36
        Filter Predicates
          T.ANO_LETIVO(+)='2003/2004'
  Other XML
```



```
OPERATION                             OBJECT_NAME                OPTIONS                  CARDINALITY   COST
SELECT STATEMENT                                                                                 1028     58
  FILTER
    Filter Predicates
      T.ID IS NULL
    HASH JOIN                                                    OUTER                           1028     58
      Access Predicates
        AND
          O.ANO_LETIVO=T.ANO_LETIVO(+)
          O.PERIODO=T.PERIODO(+)
          O.CODIGO=T.CODIGO(+)
      INDEX                           ZOCORRENCIAS_PK            FAST FULL SCAN                  1028     27
        Filter Predicates
          O.ANO_LETIVO='2003/2004'
      TABLE ACCESS                    ZTIPOSAULA                 BY INDEX ROWID BATCHED          1588     31
        INDEX                         TIPOSAULA_IDX_ANOLETIVO    RANGE SCAN                      1588      5
          Access Predicates
            T.ANO_LETIVO(+)='2003/2004'
  Other XML
```

The usage of the primary keys codigo, periodo and ano_letivo improved the cost in environment y.

The usage of the index tiposaula_idx_anoletivo improved the cost of filtering the ano_letivo in environment z.

4) if the execution time is measurable, a comparison of the execution times in the three environments.

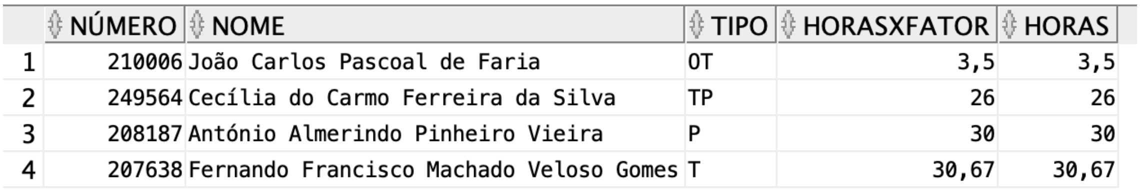
Environment	Execution Time (ms)
Environment X	91
Environment Y	89
Environment Z	84

Query 4 - Who is the professor with more class hours for each type of class, in the academic year 2003/2004? Show the number and name of the professor, the type of class and the total of class hours times the factor.

1) the SQL query;

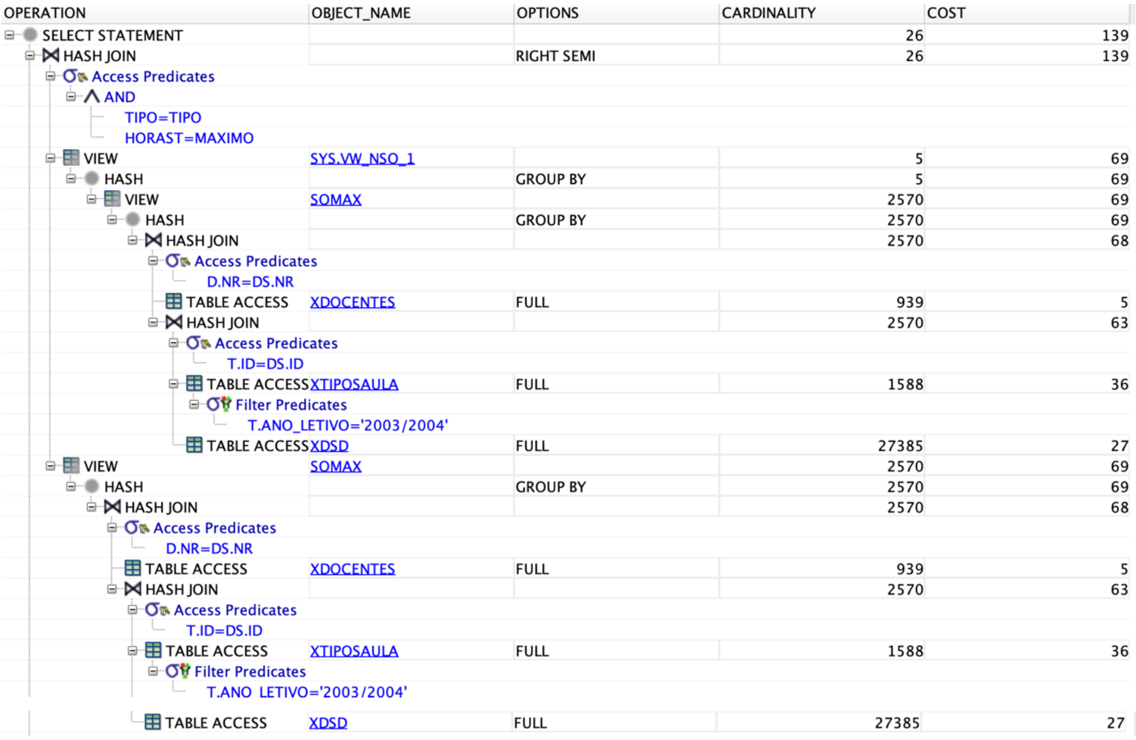
```
CREATE OR REPLACE VIEW somax AS
SELECT d.nome, d.nr, ds.fator, t.tipo, SUM(ds.horas) horasT
FROM xdsd ds
JOIN xdocentes d ON d.nr=ds.nr
JOIN xtiposaula t ON t.id=ds.id
WHERE t.ano_letivo='2003/2004'
GROUP BY t.tipo, d.nr,d.nome,ds.fator;

SELECT nr número, nome, tipo, horasT*fator horasxfator, horasT horas FROM
somax WHERE (tipo, horasT) IN (
SELECT tipo, MAX(horasT) maximo FROM somax GROUP BY tipo);
```

2) the answer;

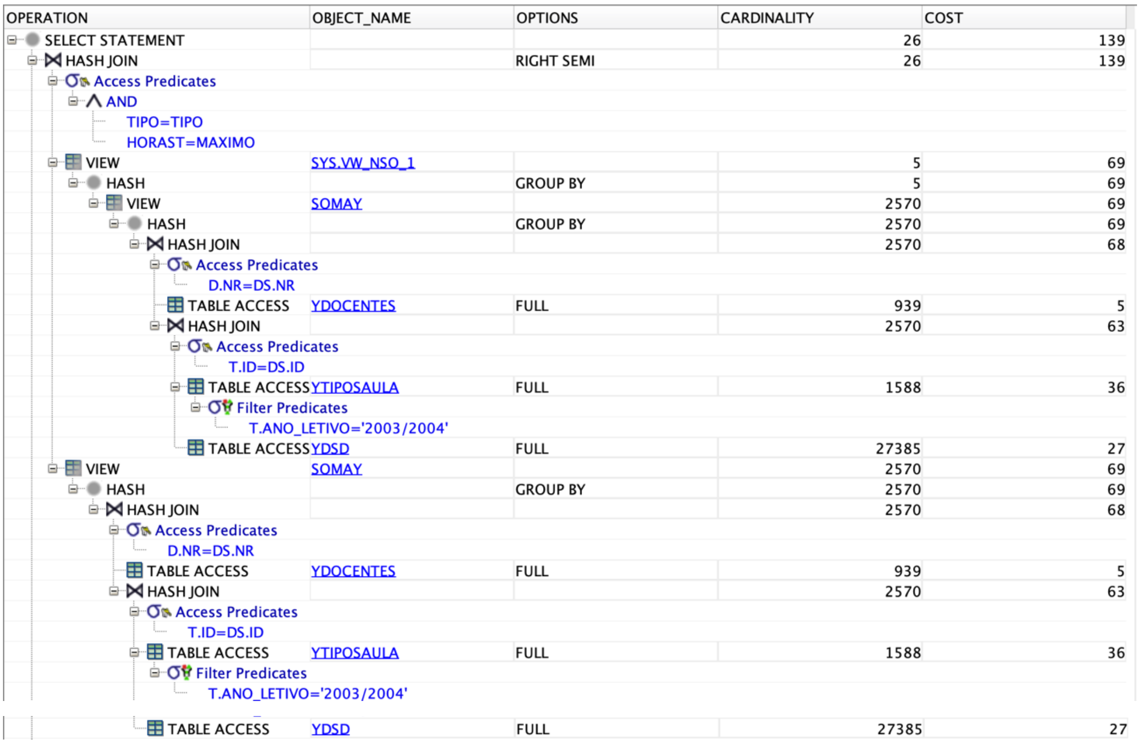


	NÚMERO	NOME	TIPO	HORASXFATOR	HORAS
1	210006	João Carlos Pascoal de Faria	OT	3,5	3,5
2	249564	Cecília do Carmo Ferreira da Silva	TP	26	26
3	208187	António Almerindo Pinheiro Vieira	P	30	30
4	207638	Fernando Francisco Machado Veloso Gomes	T	30,67	30,67

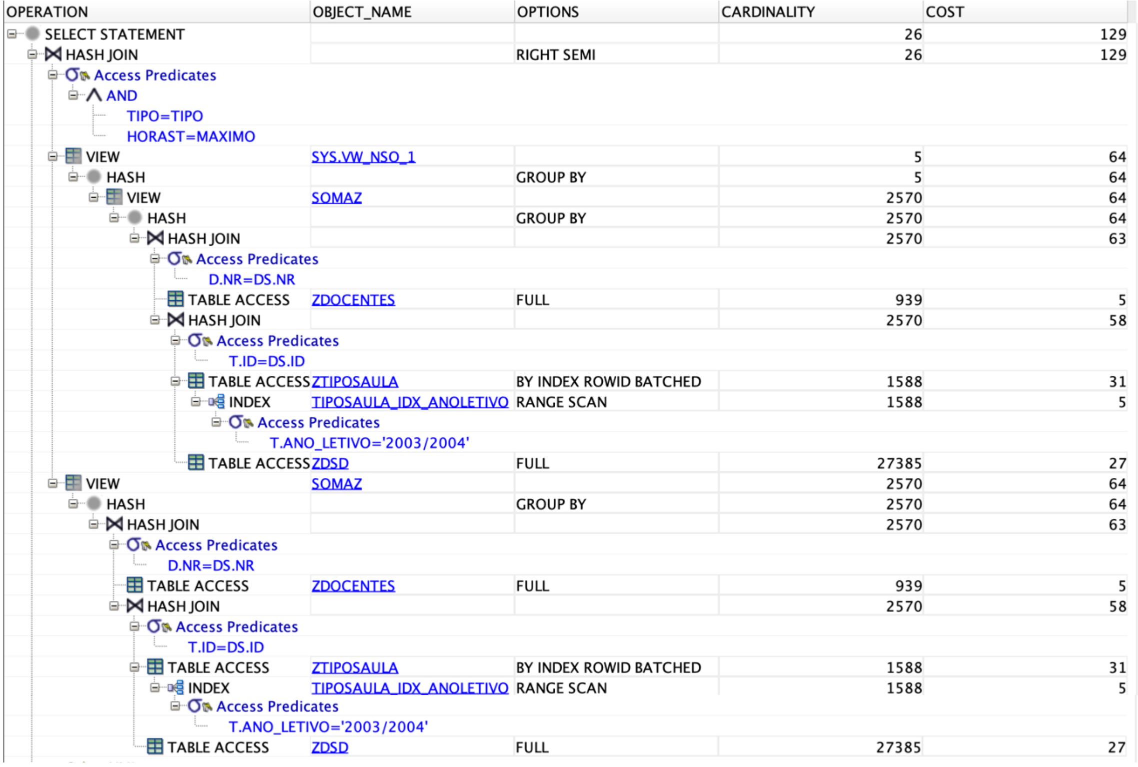
3) the three execution plans in the three environments, their analysis and of the corresponding estimated effort;



```
OPERATION                                  OBJECT_NAME    OPTIONS       CARDINALITY   COST
SELECT STATEMENT                                                                 26    139
  HASH JOIN                                               RIGHT SEMI             26    139
    Access Predicates
      AND
        TIPO=TIPO
        HORAST=MAXIMO
    VIEW                                   SYS.VW_NSO_1                           5     69
      HASH                                                GROUP BY                5     69
        VIEW                               SOMAX                               2570     69
          HASH                                            GROUP BY             2570     69
            HASH JOIN                                                          2570     68
              Access Predicates
                D.NR=DS.NR
              TABLE ACCESS                 XDOCENTES      FULL                  939      5
              HASH JOIN                                                        2570     63
                Access Predicates
                  T.ID=DS.ID
                TABLE ACCESS               XTIPOSAULA     FULL                 1588     36
                  Filter Predicates
                    T.ANO_LETIVO='2003/2004'
                TABLE ACCESS               XDSD           FULL                27385     27
    VIEW                                   SOMAX                               2570     69
      HASH                                                GROUP BY             2570     69
        HASH JOIN                                                              2570     68
          Access Predicates
            D.NR=DS.NR
          TABLE ACCESS                     XDOCENTES      FULL                  939      5
          HASH JOIN                                                            2570     63
            Access Predicates
              T.ID=DS.ID
            TABLE ACCESS                   XTIPOSAULA     FULL                 1588     36
              Filter Predicates
                T.ANO_LETIVO='2003/2004'
            TABLE ACCESS                   XDSD           FULL                27385     27
```



OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY	COST
SELECT STATEMENT			26	139
HASH JOIN		RIGHT SEMI	26	139
Access Predicates				
AND				
TIPO=TIPO				
HORAST=MAXIMO				
VIEW	SYS.VW_NSO_1		5	69
HASH		GROUP BY	5	69
VIEW	SOMAY		2570	69
HASH		GROUP BY	2570	69
HASH JOIN			2570	68
Access Predicates				
D.NR=DS.NR				
TABLE ACCESS	YDOCENTES	FULL	939	5
HASH JOIN			2570	63
Access Predicates				
T.ID=DS.ID				
TABLE ACCESS	YTIPOSAULA	FULL	1588	36
Filter Predicates				
T.ANO_LETIVO='2003/2004'				
TABLE ACCESS	YDSD	FULL	27385	27
VIEW	SOMAY		2570	69
HASH		GROUP BY	2570	69
HASH JOIN			2570	68
Access Predicates				
D.NR=DS.NR				
TABLE ACCESS	YDOCENTES	FULL	939	5
HASH JOIN			2570	63
Access Predicates				
T.ID=DS.ID				
TABLE ACCESS	YTIPOSAULA	FULL	1588	36
Filter Predicates				
T.ANO_LETIVO='2003/2004'				
TABLE ACCESS	YDSD	FULL	27385	27



OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY	COST
SELECT STATEMENT			26	129
HASH JOIN		RIGHT SEMI	26	129
Access Predicates				
AND				
TIPO=TIPO				
HORAST=MAXIMO				
VIEW	SYS.VW_NSO_1		5	64
HASH		GROUP BY	5	64
VIEW	SOMAZ		2570	64
HASH		GROUP BY	2570	64
HASH JOIN			2570	63
Access Predicates				
D.NR=DS.NR				
TABLE ACCESS	ZDOCENTES	FULL	939	5
HASH JOIN			2570	58
Access Predicates				
T.ID=DS.ID				
TABLE ACCESS	ZTIPOSAULA	BY INDEX ROWID BATCHED	1588	31
INDEX	TIPOSAULA_IDX_ANOLETIVO	RANGE SCAN	1588	5
Access Predicates				
T.ANO_LETIVO='2003/2004'				
TABLE ACCESS	ZDSD	FULL	27385	27
VIEW	SOMAZ		2570	64
HASH		GROUP BY	2570	64
HASH JOIN			2570	63
Access Predicates				
D.NR=DS.NR				
TABLE ACCESS	ZDOCENTES	FULL	939	5
HASH JOIN			2570	58
Access Predicates				
T.ID=DS.ID				
TABLE ACCESS	ZTIPOSAULA	BY INDEX ROWID BATCHED	1588	31
INDEX	TIPOSAULA_IDX_ANOLETIVO	RANGE SCAN	1588	5
Access Predicates				
T.ANO_LETIVO='2003/2004'				
TABLE ACCESS	ZDSD	FULL	27385	27

There is no improvement from environment x to y. This is due to usage of a GROUP BY function with 4 different columns, which makes it very difficult to use correct indexes that could improve the perfomance.

Between environment y to z, the index tiposaula_idx_anoletivo reduces the cost when creating the VIEW because we are filtering from ano_letivo column.

4) if the execution time is measurable, a comparison of the execution times in the three environments.

Environment	Execution Time (ms)
Environment X	100
Environment Y	98
Environment Z	89

Query 5 - Compare the execution plans (just the environment Z) and the index sizes for the query giving the course code, the academic year, the period, and number of hours of the type ‘OT’ in the academic years of 2002/2003 and 2003/2004.

a. With a B-tree index on the type and academic year columns of the ZTIPOSAULA table;

b. With a bitmap index on the type and academic year columns of the ZTIPOSAULA table.

1) the SQL query;

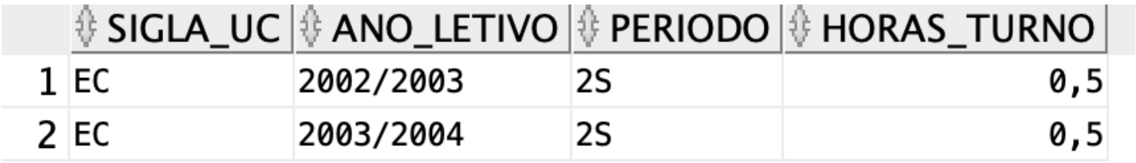
a.

```
CREATE INDEX tiposaula_idx ON ztiposaula (tipo, ano_letivo);

SELECT u.sigla_uc, o.ano_letivo, o.periodo, s.horas_turno
FROM ztiposaula s JOIN zocorrencias o ON o.codigo=s.codigo AND
o.ano_letivo=s.ano_letivo AND o.periodo=s.periodo
JOIN zucs u ON u.codigo = o.codigo
WHERE s.tipo='OT' AND s.ano_letivo LIKE '%2003%';
```

b.

```
DROP INDEX tiposaula_idx;
CREATE BITMAP INDEX tiposaula_idx ON ztiposaula (tipo, ano_letivo);

SELECT u.sigla_uc, o.ano_letivo, o.periodo, s.horas_turno
FROM ztiposaula s JOIN zocorrencias o ON o.codigo=s.codigo AND
o.ano_letivo=s.ano_letivo AND o.periodo=s.periodo
JOIN zucs u ON u.codigo = o.codigo
WHERE s.tipo='OT' AND s.ano_letivo LIKE '%2003%';
```

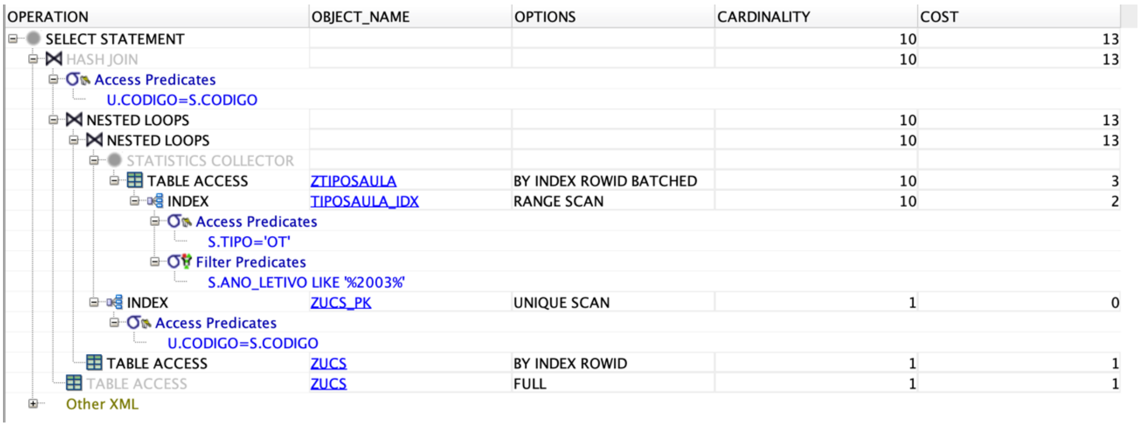
2) the answer;



	SIGLA_UC	ANO_LETIVO	PERIODO	HORAS_TURNO
1	EC	2002/2003	2S	0,5
2	EC	2003/2004	2S	0,5

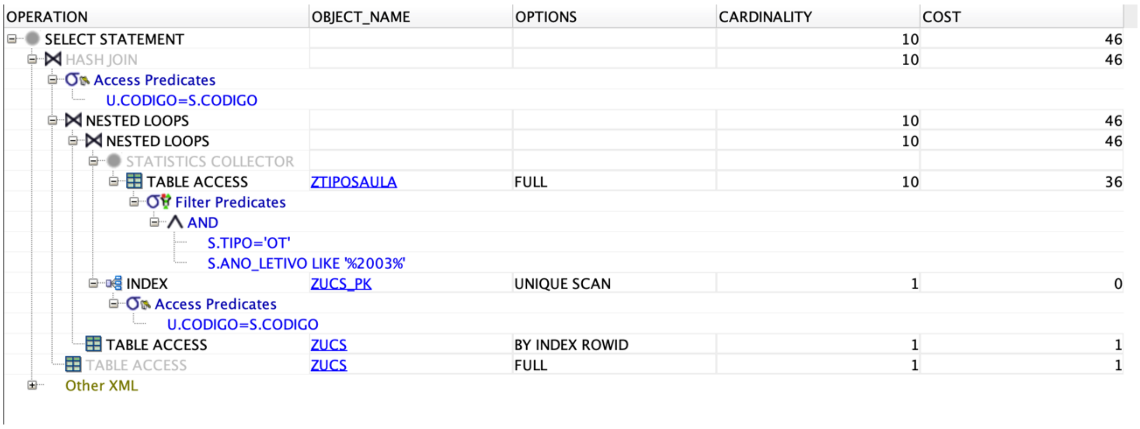
3) the three execution plans in the three environments, their analysis and of the corresponding estimated effort;

a.



OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY	COST
SELECT STATEMENT			10	13
HASH JOIN			10	13
Access Predicates				
U.CODIGO=S.CODIGO				
NESTED LOOPS			10	13
NESTED LOOPS			10	13
STATISTICS COLLECTOR				
TABLE ACCESS	ZTIPOSAULA	BY INDEX ROWID BATCHED	10	3
INDEX	TIPOSAULA_IDX	RANGE SCAN	10	2
Access Predicates				
S.TIPO='OT'				
Filter Predicates				
S.ANO_LETIVO LIKE '%2003%'				
INDEX	ZUCS_PK	UNIQUE SCAN	1	0
Access Predicates				
U.CODIGO=S.CODIGO				
TABLE ACCESS	ZUCS	BY INDEX ROWID	1	1
TABLE ACCESS	ZUCS	FULL	1	1
Other XML				

b.



OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY	COST
SELECT STATEMENT			10	46
HASH JOIN			10	46
Access Predicates				
U.CODIGO=S.CODIGO				
NESTED LOOPS			10	46
NESTED LOOPS			10	46
STATISTICS COLLECTOR				
TABLE ACCESS	ZTIPOSAULA	FULL	10	36
Filter Predicates				
AND				
S.TIPO='OT'				
S.ANO_LETIVO LIKE '%2003%'				
INDEX	ZUCS_PK	UNIQUE SCAN	1	0
Access Predicates				
U.CODIGO=S.CODIGO				
TABLE ACCESS	ZUCS	BY INDEX ROWID	1	1
TABLE ACCESS	ZUCS	FULL	1	1
Other XML				

Bitmap indexes work best when the indexed columns have high cardinality, i.e., when the number of distinct values is large compared to the total number of rows in the table. That is not the case in this situation, since the cardinality is 10. For that reason, the B-tree index has a lower cost when comparing with the Bitmap index.

4) if the execution time is measurable, a comparison of the execution times in the three environments.

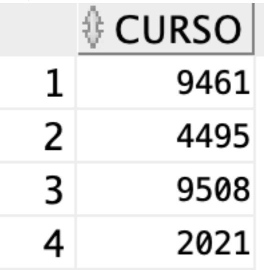
Environment	Execution Time (ms)
Environment Z_A	48
Environment Z_B	140

Query 6 - Select the programs (curso) that have classes with all the existing types.

1) the SQL query;

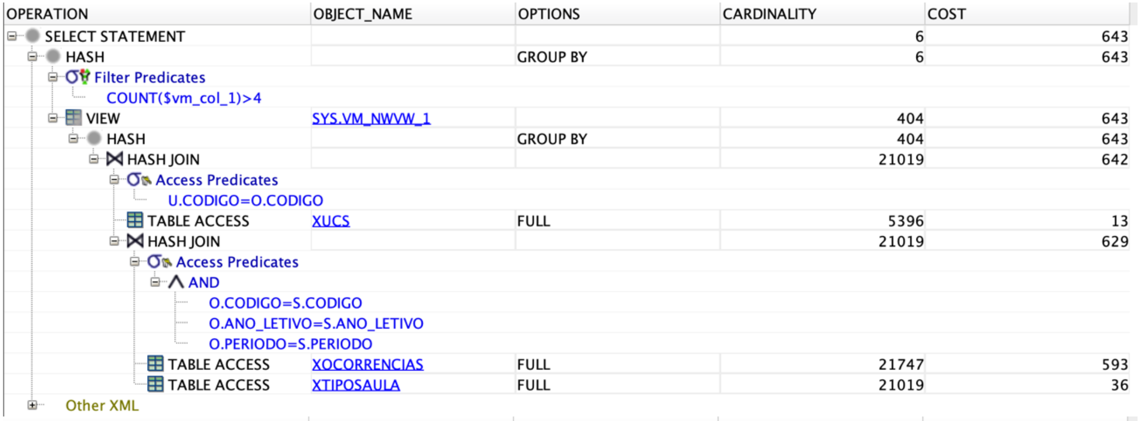
```
SELECT u.curso
FROM xucs u JOIN xocorrencias o ON u.codigo = o.codigo
JOIN xtiposaula s ON o.codigo=s.codigo AND o.ano_letivo=s.ano_letivo AND
o.periodo=s.periodo
GROUP BY u.curso HAVING COUNT(DISTINCT s.tipo)>4;
```

2) the answer;

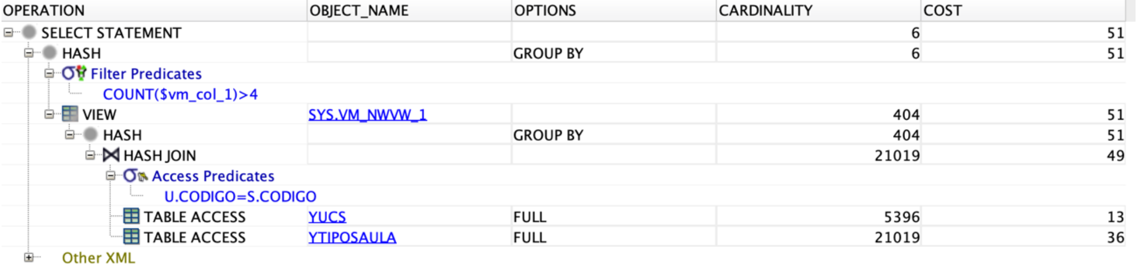


	CURSO
1	9461
2	4495
3	9508
4	2021

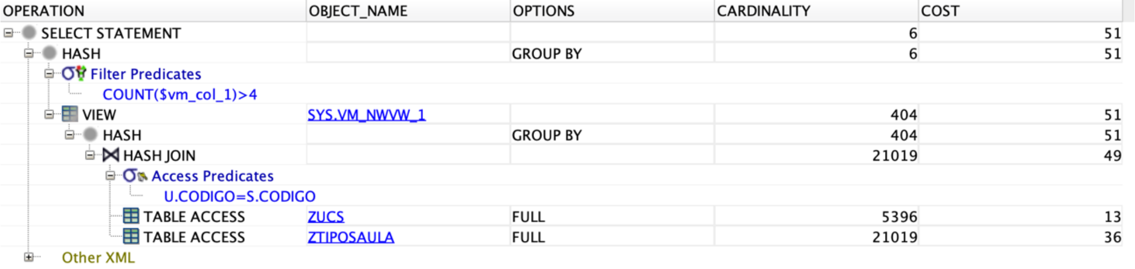
3) the three execution plans in the three environments, their analysis and of the corresponding estimated effort;



OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY	COST
SELECT STATEMENT			6	643
HASH		GROUP BY	6	643
Filter Predicates				
COUNT($vm_col_1)>4				
VIEW	SYS.VM_NWVW_1		404	643
HASH		GROUP BY	404	643
HASH JOIN			21019	642
Access Predicates				
U.CODIGO=O.CODIGO				
TABLE ACCESS	XUCS	FULL	5396	13
HASH JOIN			21019	629
Access Predicates				
AND				
O.CODIGO=S.CODIGO				
O.ANO_LETIVO=S.ANO_LETIVO				
O.PERIODO=S.PERIODO				
TABLE ACCESS	XOCORRENCIAS	FULL	21747	593
TABLE ACCESS	XTIPOSAULA	FULL	21019	36
Other XML				



OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY	COST
SELECT STATEMENT			6	51
HASH		GROUP BY	6	51
Filter Predicates				
COUNT($vm_col_1)>4				
VIEW	SYS.VM_NWVW_1		404	51
HASH		GROUP BY	404	51
HASH JOIN			21019	49
Access Predicates				
U.CODIGO=S.CODIGO				
TABLE ACCESS	YUCS	FULL	5396	13
TABLE ACCESS	YTIPOSAULA	FULL	21019	36
Other XML				



OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY	COST
SELECT STATEMENT			6	51
HASH		GROUP BY	6	51
Filter Predicates				
COUNT($vm_col_1)>4				
VIEW	SYS.VM_NWVW_1		404	51
HASH		GROUP BY	404	51
HASH JOIN			21019	49
Access Predicates				
U.CODIGO=S.CODIGO				
TABLE ACCESS	ZUCS	FULL	5396	13
TABLE ACCESS	ZTIPOSAULA	FULL	21019	36
Other XML				

The usage of the foreign keys codigo, ano_letivo and periodo improved the cost of the JOIN between yocorrencias and ytiposaula.

There is no difference in cost between environment y and z since there is not an index that could improve the performance.

4) if the execution time is measurable, a comparison of the execution times in the three environments.

Environment	**Execution Time (ms)**
Environment X	91
Environment Y	62
Environment Z	62