

**KNOWLEDGE REPRESENTATION & REASONNG - FALL 2022**

# **Higher Education Degree Programs in Pakistan (HEDPiP)**

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**Final Project Report**

# Domain Description

Graduation is a milestone leading you towards your successful career. After completing high school, every student wants to get admitted to their dream institute pursuing the dream degree program.

Luckily, some of them achieve their goal and the rest of students begin to explore other options and in doing so one could have many restrictions like; university should be in a particular city, offering a particular course with a specific fee structure.

It's a very tiresome process to find an institute that fulfills all the constraints. To tackle this problem we've developed an application using the concepts of knowledge graphs that gathers all the necessary information related to universities in Pakistan under one umbrella. The students can easily find a university, the subjects it offers along with the Tuition Fee, its credibility with the program (in terms of years) and its address. This allows for a comparative analysis between the universities for choosing the right program at the right affordable price.

## Work distribution

### **Hadia Sultan:**

Documentation, Ontology Design, Conceptual Model Design,  
Vocabularies, Identifying Dataset Linkages

### **Ahmed Raza:**

Dataset Creation, Ontology Mapping, Reasoning

### **Maaz:**

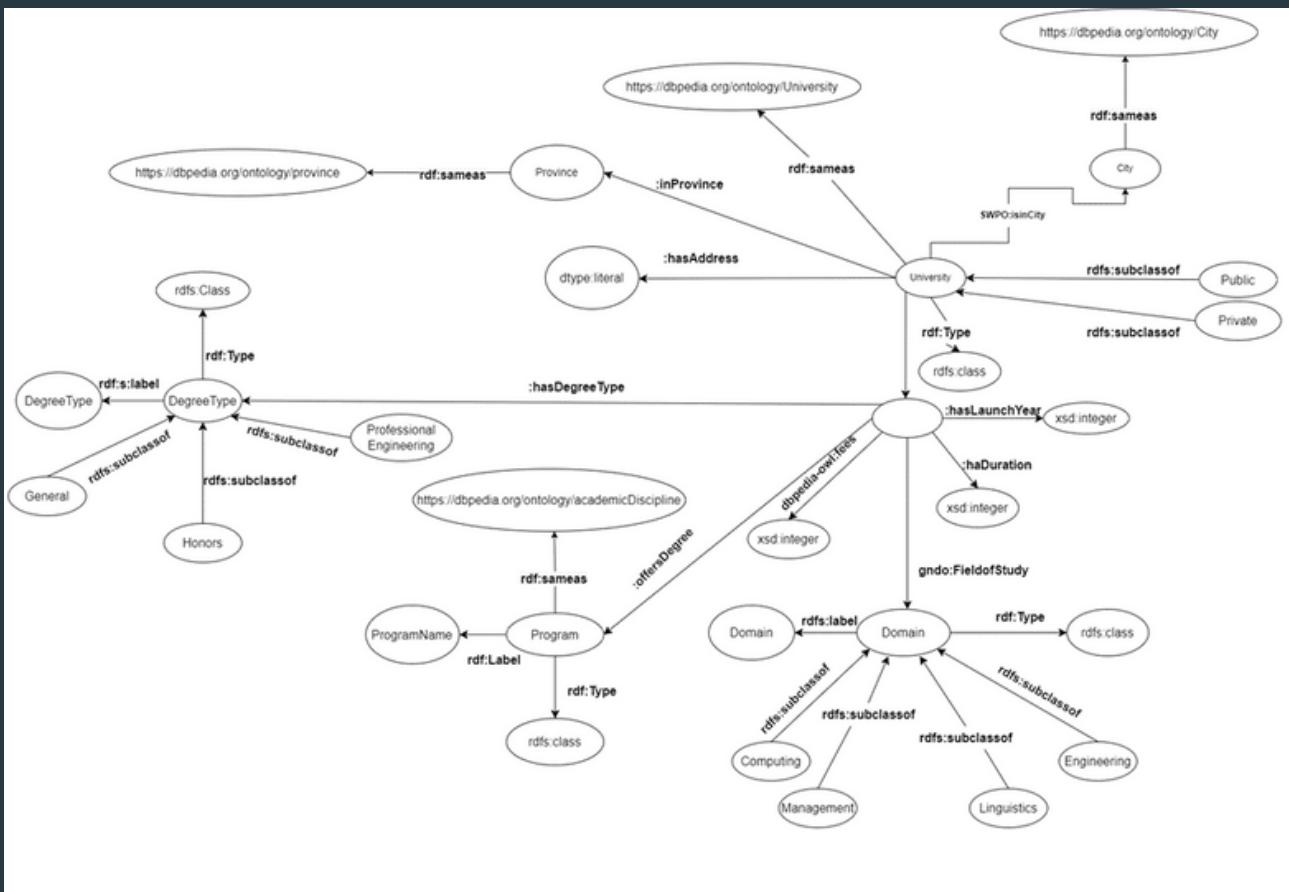
Documentation, Dataset Creation, Ontology Design, Ontology Mapping,  
SPARQL, Frontend

# Competency Questions

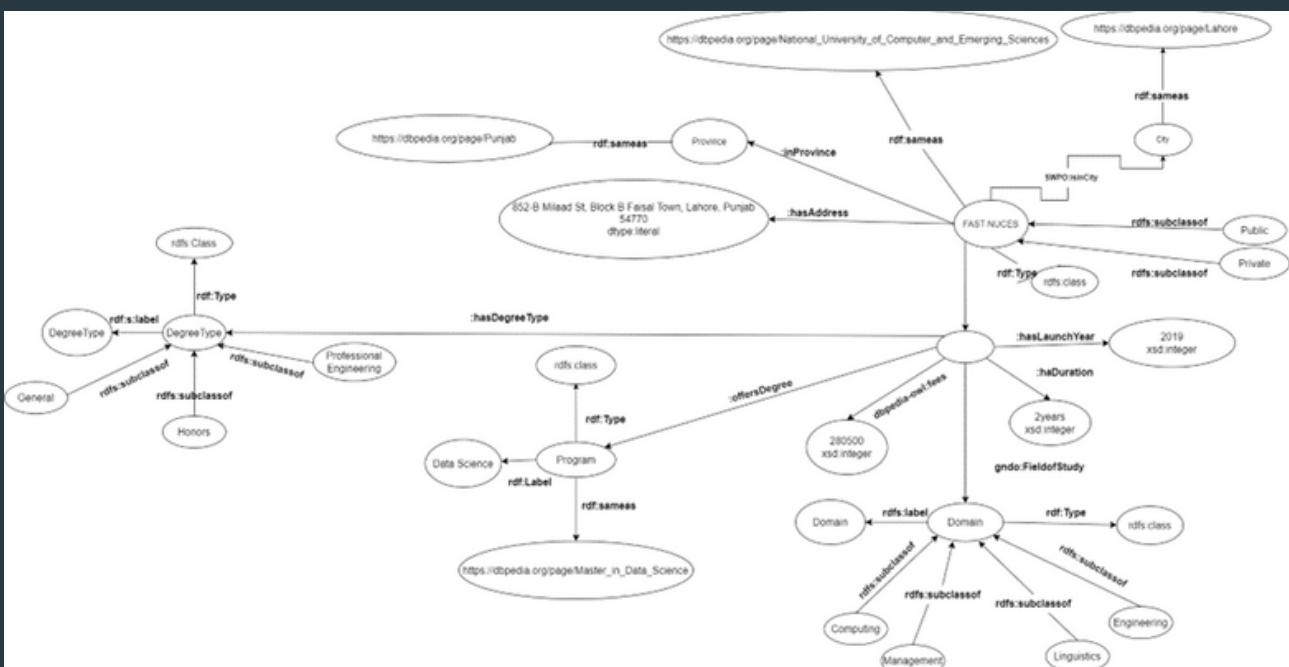
- How many universities are there in each city?
- How many universities are there in each province?
- How many public/private universities are there in each city?
- How many public/private universities are there in each province?
- Which province houses the most universities with a particular degree program?
- Which degree program has the lowest average costs?
- Which domain of study has the lowest average cost?
- Which province offers the most free of cost degree programs?
- Which domain of study offers programs other than General Bachelors?
- Which degree programs have a duration of less than 4 years?
- Which university pioneered a particular degree program?
- Which university pioneered a particular degree program in each province?
- Which degree programs, and their corresponding universities, cost less than a particular amount?
- Which degree programs, and their corresponding universities, cost less than a particular amount, in a particular city/province?
- For how many years has a university been offering a particular degree?
- What is the count of Honors and General degrees in each province?
- Which domain of study offers most Honors programs?

# Conceptual Model

## Terminology Box



## Assertion Box



# Description of Dataset

The dataset holds the details of several degree programs, ranging from a variety of domains (Computing, Management, Engineering, Social Sciences).

Some intuition was taken from the following dataset, however the dataset created is our own.

<https://www.kaggle.com/datasets/zusmani/pakistanintellectualcapitalcs>

Helping website: <https://www.eduvision.edu.pk/>

The columns of the dataset are briefly described below:

- University Name:** Name of the campus offering a particular degree.
- Address:** Address of the campus offering a particular degree.
- City:** City of the campus offering a particular degree.
- Province:** Province of the campus offering a particular degree.
- Type:** Is the university public sector or private sector?
- Program:** What is the degree program being offered?
- Degree Type:** Is it a general degree or an Honors degree?
- Domain:** What is the domain of study?
- Annual Fee:** What is the annual fee of this degree program with respect to the campus?
- Program Launch Year:** When was this degree launched at this campus?
- Duration (Years):** How long is the coursework of this degree program at this campus?

The dataset has 67 rows and 11 columns. It is based on information related to different universities of Pakistan. The university name can be replicated with different programs for example NUCES, FAST has more than one campus and each of them offer different degree programs.

To accurately model the scenario that the same degree program such as BS Computer Science may be the 'same' program for all universities that offer it, but its starting year, duration and tuition fee may differ from campus to campus, we have used a blank node that models each degree program with respect to each university campus.

A	B	C	D	E	F	G	H	I	J	K
University Name	Address	City	Province	Type	Program	DegreeType	Domain	Annual Fee	Program Launch Year	Duration (Years)
University of Kotli	Village Kurti	Kotli	Azad Jammu and Kashmir	Public	BS Artificial Intelligence	General	Computing	0	2020	4
Air University - Islamabad	E-8	Islamabad	Islamabad	Public	BS Artificial Intelligence	General	Computing	162340	2019	4
NUCES, FAST - Karachi	National Highway	Karachi	Sindh	Private	BS Artificial Intelligence	General	Computing	292000	2020	4
The Islamia University Of Bahawalpur	Girls College Road	Bahawalpur	Punjab	Public	BS Artificial Intelligence	General	Computing	47800	2020	4
Sindh Madressatul Islam University	Anwan-e-Tijarat Road	Karachi	Sindh	Public	BS Artificial Intelligence	General	Computing	70000	2021	4
NUCES, FAST - Islamabad	H-11/4	Islamabad	Islamabad	Private	BS Artificial Intelligence	General	Computing	292000	2019	4
NUCES, FAST - Islamabad	H-11/4	Islamabad	Islamabad	Private	BS Data Science	General	Computing	292000	2019	4
The Islamia University Of Bahawalpur	Girls College Road	Bahawalpur	Punjab	Public	BS Data Science	General	Computing	47800	2020	4
Lahore University of Management Sciences	Khayab-e-Jinnah	Lahore	Punjab	Private	BS Computer Science	Honors	Computing	811100	1994	4
Air University - Islamabad	E-8	Islamabad	Islamabad	Public	BS Computer Science	General	Computing	110000	2002	4
Abdul Wali Khan University	Nowshera Mardan Roa Mardan	Khyber Pakhtunkhwa	Public	BS Computer Science	General	Computing	75440	2009	4	
NUCES, FAST - Islamabad	H-11/4	Islamabad	Islamabad	Private	BS Computer Science	Honors	Computing	292000	2000	4
University Of Malakand	Chakdara, Lower Dir	Chakdara	Khyber Pakhtunkhwa	Public	Bachelors of Business Administration	General	Management	0	2001	4
Mir Chakar Khan Rind University Of Technology	Sakhi Sarwar Road	DG Khan	Punjab	Public	Bachelors of Business Administration	General	Management	0	2019	4
University Of Science & Technology	Kohat Road	Bannu	Khyber Pakhtunkhwa	Public	Bachelors of Business Administration	Honors	Management	32800	2005	4
University Of Azad Jammu & Kashmir	CMH Road	Muzaffarabad	Azad Jammu and Kashmir	Public	Bachelors of Business Administration	General	Management	0	1980	3
Pir Mahro Ali Shah Arid Agriculture University	Murree Road	Rawalpindi	Punjab	Public	Bachelors of Business Administration	General	Management	41800	1994	2
Pir Mahro Ali Shah Arid Agriculture University	Murree Road	Rawalpindi	Punjab	Public	Bachelors of Business Administration	Honors	Management	41800	1994	4
Greenwich University	DHA Phase 6	Karachi	Sindh	Public	BS Management	General	Management	132110	1987	4
Government College University Faisalabad (Layyah Sugar Mill Road	Layyah	Punjab	Public	AD Management	General	Management	0	2011	2	
Government College University Faisalabad (Layyah Sugar Mill Road	Layyah	Punjab	Public	Bachelors of Business Administration	Honors	Management	0	2011	2	
University of Sargodha	University Road	Sargodha	Punjab	Public	BS Mechanical Engineering	General	Engineering	76750	2013	4
University of Sargodha	University Road	Sargodha	Punjab	Public	BS Civil Engineering	General	Engineering	76750	2013	4
University of Sargodha	University Road	Sargodha	Punjab	Public	BS Electrical Engineering	General	Engineering	76750	2013	4

# Identified for Re-use

## [Vocabularies & Entities]

### VOCABULARIES

DBPEDIA-OWL:FEES  
GND0:FIELD0FSTUDY  
SWPO:INCITY

### RESOURCES

PREFIX : HTTP://DBPEDIA.ORG/RESOURCE/

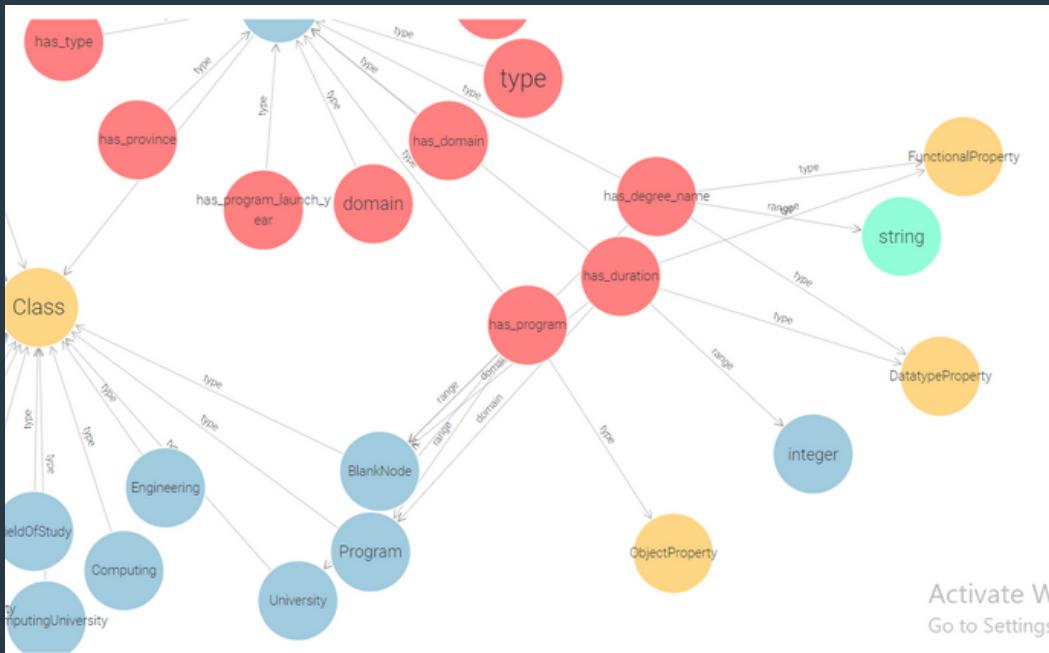
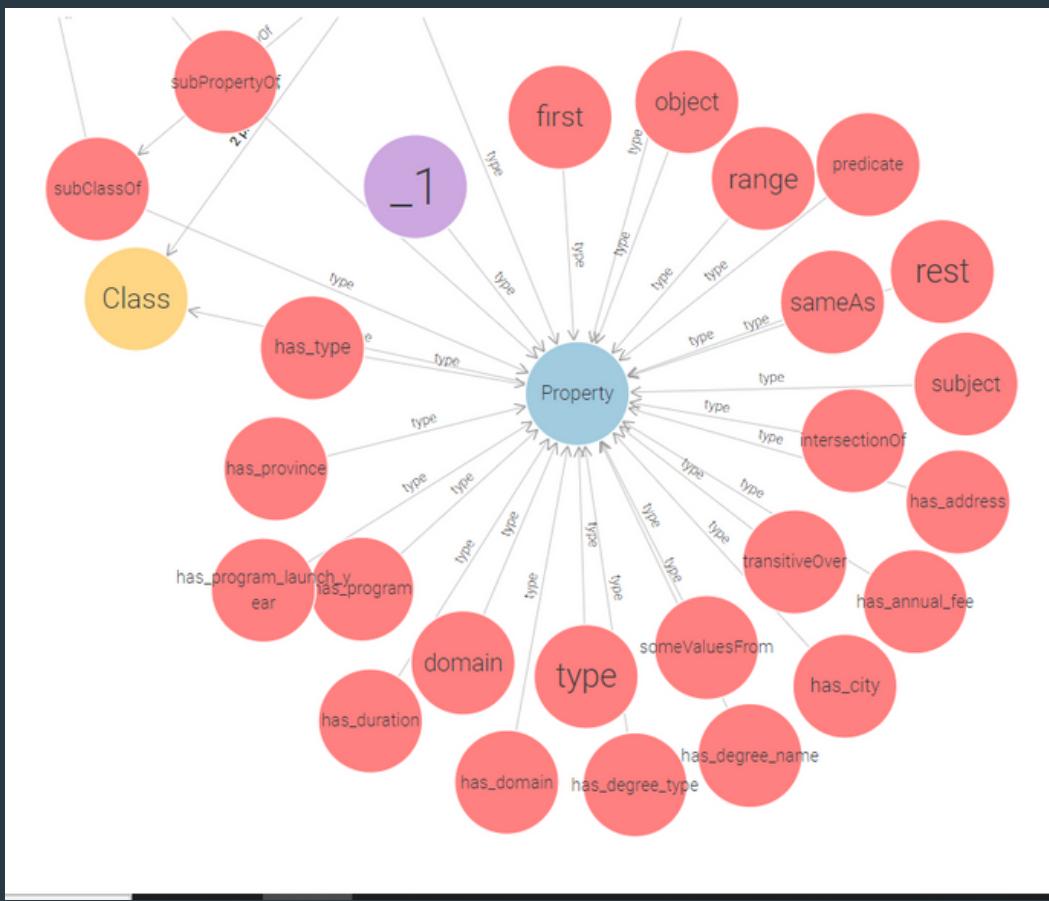
:NATIONAL\_UNIVERSITY\_OF\_COMPUTER\_AND\_EMERGING SCIENCES

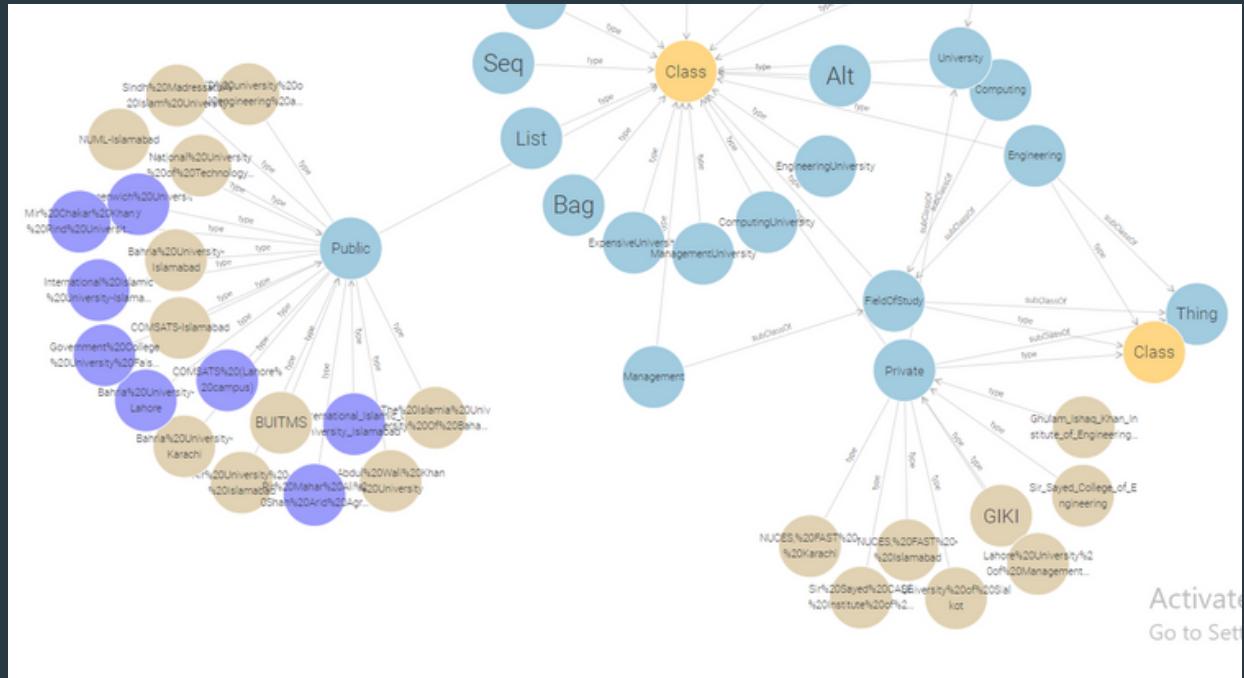
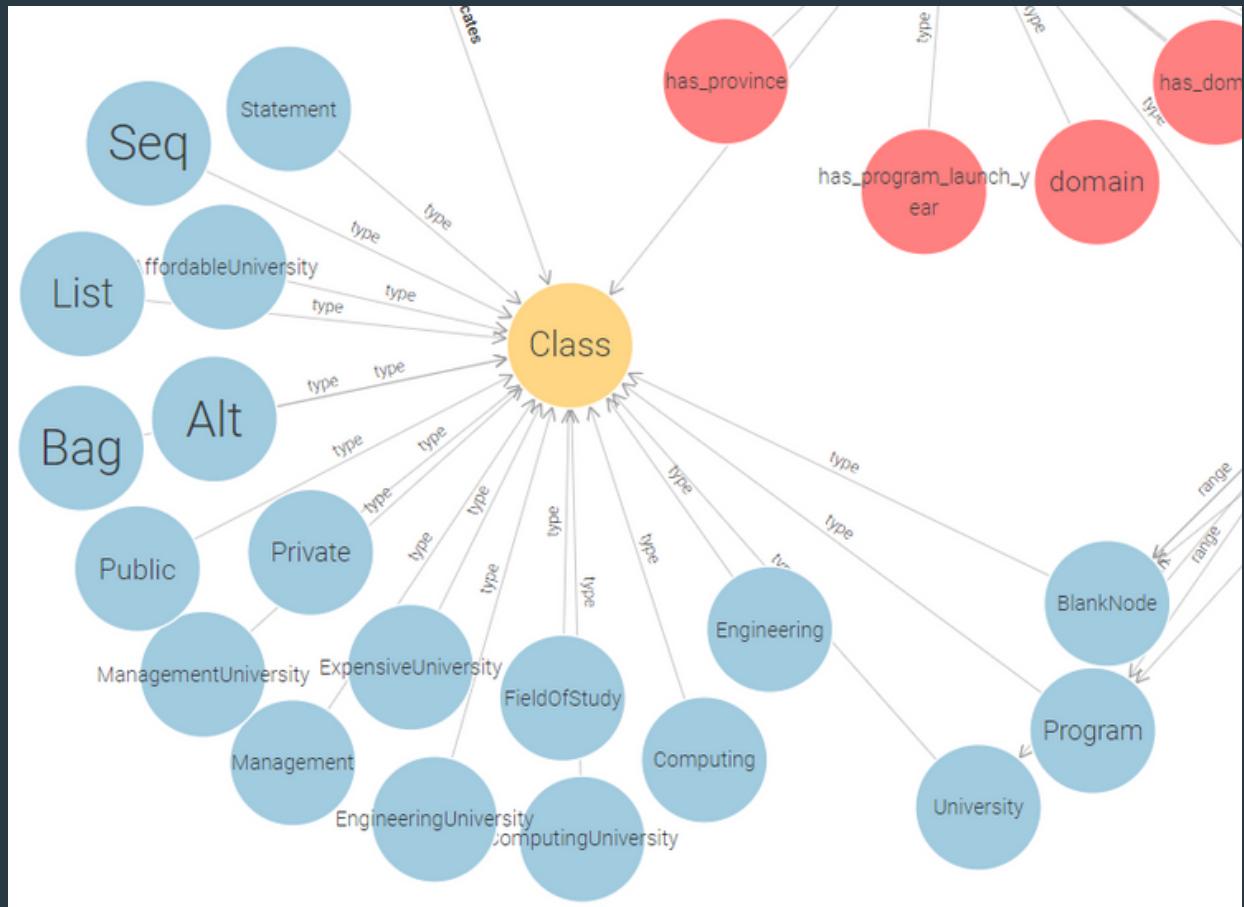
:GHULAM\_ISHAQ\_KHAN\_INSTITUTE\_OF\_ENGINEERING SCIENCES\_AND TECHNOLOGY

:SIR\_SAYED\_COLLEGE\_OF\_ENGINEERING

:INTERNATIONAL\_ISLAMIC\_UNIVERSITY\_ISLAMABAD

# GraphDB Visualization





# Reasoning and its significance

To add more value to our ontology, we created two new classes solely for the purpose of modeling a reasoning scenario that classifies in some classes that we may generally classify when considering an institution. The idea of these classes resonates with the intended goal of this ontology and helps the users add value to their institution search.

The classes used to get reasoning are as follows:

## 1. UniversityCost (Disjoint Sub-classes)

- a. **Expensive University** - A university with some programs costing above 100,000
- b. **Affordable University** - A university with some programs costing below 40,000

## 2. UniversityDomain (Non Disjoint Sub-classes)

- a. **ComputingUniversity** - A university that offers some programs of domain Computing
- b. **EngineeringUniversity** - A university that offers some programs of domain Engineering
- c. **ManagementUniversity** - A university that offers some programs of domain Management

## Example 1

**NUCES, FAST Islamabad offering BS Data Science, a Computing Program,  
with Tuition Fee Rs. 292,000 Per Annum**

**NUCES, FAST Islamabad offering BS Mechanical Engineering, an Engineering Program,  
with Tuition Fee Rs. 92,000 Per Annum**

## Reasoning

**NUCES, FAST Islamabad is an ExpensiveUniversity**

**NUCES, FAST Islamabad is a ComputingUniversity**

**NUCES, FAST Islamabad is an Engineering University**

Active ontology | Entities | Individuals by class | DL Query

Data properties Annotation properties Datatypes Individuals

Classes Object properties

**Class hierarchy: AffordableUniversity**

owl:Thing AffordableUniversity ComputingUniversity EngineeringUniversity ExpensiveUniversity FieldOfStudy ManagementUniversity Program University

**Annotations: AffordableUniversity**

Description: AffordableUniversity

Equivalent To +

University  
and (has\_program some (has\_annual\_fee some xsd:integer(<= 80000)))  
and (has\_program some (has\_annual\_fee only xsd:integer)))

SubClass Of +

owl:Thing  
University

General class axioms

SubClass Of (Anonymous Ancestor)

Instances +

- "COMSATS%20(Lahore%20campus)"
- "Government%20(College%20University%20Faisalabad%20(Layyah%20Campus))"
- "NUCES,%20FAST%20-%20Islamabad"
- Abdul%20Wali%20Khan%20University
- Air%20University%20-%20Islamabad
- Bahria%20University-Karachi
- Bahria%20University-Lahore
- BUTMS
- dbpedia:Gulam\_Ishaq\_Khan\_Institute\_of\_Engineering\_Sciences\_and\_Technology
- GIKI

Reasoner active  Show Instances

Active ontology | Entities | Individuals by class | DL Query

Data properties Annotation properties Datatypes Individuals

Classes Object properties

**Class hierarchy: ExpensiveUniversity**

owl:Thing AffordableUniversity ComputingUniversity EngineeringUniversity ExpensiveUniversity FieldOfStudy ManagementUniversity Program University

**Annotations: ExpensiveUniversity**

Description: ExpensiveUniversity

Equivalent To +

University  
and (has\_program some (has\_annual\_fee some xsd:integer(> 100000)))  
and (has\_program some (has\_annual\_fee only xsd:integer)))

SubClass Of +

owl:Thing  
University

General class axioms

SubClass Of (Anonymous Ancestor)

Instances +

- "NUCES,%20FAST%20-%20Islamabad"
- "NUCES,%20FAST%20-%20Karachi"
- 'dbpedia:International\_Islamic\_University\_Islamabad'
- Air%20University%20-%20Islamabad
- Bahria%20University-Islamabad
- Bahria%20University-Karachi
- COMSATS-Islamabad
- dbpedia:Gulam\_Ishaq\_Khan\_Institute\_of\_Engineering\_Sciences\_and\_Technology
- dbpedia:Sir\_Sayed\_College\_of\_Engineering
- GIKI

Reasoner active  Show Instances

# SPARQL answers the Competency Questions

How many universities are there in each city?

```
SELECT ?city (COUNT(?uni) as ?count_uni)
WHERE
{
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_city> ?city.
} GROUP BY ?city
ORDER BY DESC (?count_uni)
```

The screenshot shows the GraphDB interface. On the left is a sidebar with icons for Import, Explore, SPARQL (which is highlighted in orange), Monitor, and Setup. The main area is titled "SPARQL Query & Update". A query editor window titled "Query 1" contains the SPARQL code shown above. To the right of the query are several icons: a save icon, a folder icon, a link icon, a double-right arrow icon, and a user icon. Below the query editor is a table with two columns: "city" and "count\_uni". The table contains 11 rows of data.

	city	count_uni
1	"Islamabad"	*10^^xsd:integer
2	"Karachi"	*5^^xsd:integer
3	"Lahore"	*4^^xsd:integer
4	"Quetta"	*2^^xsd:integer
5	"Swabi"	*2^^xsd:integer
6	"Bahawalpur"	*1^^xsd:integer
7	"Bannu"	*1^^xsd:integer
8	"Chakdara"	*1^^xsd:integer
9	"DG Khan"	*1^^xsd:integer
10	"Gujrat"	*1^^xsd:integer
11	"Kotli"	*1^^xsd:integer

## How many universities are there in each province?

```
SELECT ?prov (COUNT(?uni) as ?count_uni)
WHERE
{
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_province> ?prov.
}
GROUP BY ?prov
ORDER BY DESC (?count_uni)
```

The screenshot shows a SPARQL query interface with the following details:

**Query Editor:**

```
1 SELECT ?prov (COUNT(?uni) as ?count_uni)
2 WHERE
3 {
4     ?uni
5         <http://www.example.com/ontology/university_ontology.owl#has_province> ?prov.
6     } GROUP BY ?prov
7 ORDER BY DESC (?count_uni)
```

**Run** button and keyboard shortcuts are visible.

**Results:**

	prov	count_uni
1	"Punjab"	"11"^^xsd:integer
2	"Islamabad"	"10"^^xsd:integer
3	"Khyber Pakhtunkhwa"	"6"^^xsd:integer
4	"Sindh"	"5"^^xsd:integer
5	"Balochistan"	"3"^^xsd:integer
6	"Azad Jammu and Kashmir"	"2"^^xsd:integer

## How many public universities in each city

```
SELECT ?city (COUNT(?uni) as ?uni_count)
WHERE
{
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_type> "Private".
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_city> ?city.
}
GROUP BY ?city
```

The screenshot shows a SPARQL query interface with the following details:

**Query Editor:**

```
1 SELECT ?city (COUNT(?uni) as ?uni_count)
2 WHERE
3 {
4     ?uni
5         <http://www.example.com/ontology/university_ontology.owl#has_type>
6             "Private".
7         ?uni
8             <http://www.example.com/ontology/university_ontology.owl#has_city>
9                 ?city.
10        } GROUP BY ?city
```

**Run** button and keyboard shortcuts are visible.

**Results:**

	city	uni_count
1	"Swabi"	"2"^^xsd:integer
2	"Islamabad"	"3"^^xsd:integer
3	"Lahore"	"1"^^xsd:integer
4	"Karachi"	"1"^^xsd:integer
5	"Sialkot"	"1"^^xsd:integer

## How many private universities are there in each province?

```
SELECT ?province (COUNT(?uni) as ?uni_count)
WHERE
{
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_type> "Private".
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_province> ?province.
}
GROUP BY ?province
```

The screenshot shows a SPARQL query interface with the following details:

- Query 1:** The query is displayed in the editor.
- Results:** The results are presented in a table format.
- Table Headers:** The columns are labeled "province" and "uni\_count".
- Data:** There are four rows of data:
  - 1 "Khyber Pakhtunkhwa" "+2"^^xsd:integer
  - 2 "Islamabad" "+3"^^xsd:integer
  - 3 "Punjab" "+2"^^xsd:integer
  - 4 "Sindh" "+1"^^xsd:integer
- Buttons:** On the right side, there are several orange icons for file operations (Save, Open, Copy, Print, etc.) and a red "Run" button at the bottom.

## Which province houses most universities offering BS AI?

```
SELECT ?p (COUNT(?p) as ?num_p)
WHERE
{
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.
    ?prog <http://www.example.com/ontology/university_ontology.owl#has_degree_name> "BS Artificial Intelligence".
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_province> ?p
}
GROUP BY ?p
ORDER BY DESC (?num_p)
LIMIT 1
```

The screenshot shows a SPARQL query interface with the following details:

- Query 1:** The query is displayed in the editor.
- Results:** The results are presented in a table format.
- Table Headers:** The columns are labeled "p" and "num\_p".
- Data:** There is one row of data:
  - 1 "Islamabad" "+3"^^xsd:integer
- Buttons:** On the right side, there are several orange icons for file operations (Save, Open, Copy, Print, etc.) and a red "Run" button at the bottom.

## Which Degree Program has lowest average cost

```
SELECT ?name (AVG(?fee) as ?avg)
WHERE {
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.
    ?prog <http://www.example.com/ontology/university_ontology.owl#has_degree_name> ?name.
    ?prog <http://www.example.com/ontology/university_ontology.owl#has_annual_fee> ?fee.
} GROUP BY ?name
ORDER BY (?avg)
LIMIT 5
```

SPARQL Query & Update

Query 1 X Unnamed X Query 2 X Query 3 X Query 4 X Query 5 X Query 6 X Editor only Editor and results Results only Download as

```
1 SELECT ?name (AVG(?fee) as ?avg) WHERE {
2     ?uni
3         <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.
4         ?prog
5             <http://www.example.com/ontology/university_ontology.owl#has_degree_name> ?name.
6             ?prog
7                 <http://www.example.com/ontology/university_ontology.owl#has_annual_fee> ?fee.
8 } GROUP BY ?name
9 ORDER BY (?avg)
10 LIMIT 5
```

Table Raw Response Pivot Table Google Chart

Filter query results Showing results from 1 to 5 of 5. Query took 0.1s, moments ago.

	name	avg
1	'AD Management'	'0'^^xsd:decimal
2	'BS Balochi'	'16000'^^xsd:decimal
3	'BS Business and information Technology'	'21800'^^xsd:decimal
4	'AD Physics'	'33400'^^xsd:decimal
5	'Bachelors of Business Administration'	'37812.6'^^xsd:decimal

## Which Domain of study has lowest average cost?

```
SELECT ?name (AVG(?fee) as ?avg)
WHERE
{
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.
    ?prog <http://www.example.com/ontology/university_ontology.owl#has_domain> ?name.
    ?prog <http://www.example.com/ontology/university_ontology.owl#has_annual_fee> ?fee.
}
GROUP BY ?name
ORDER BY (?avg)
LIMIT 1
```

Query 1 X Unnamed X Query 2 X Query 3 X Query 4 X Query 5 X Query 6 X Query 7 X Editor only Editor and results Results only Download as

```
1 SELECT ?name (AVG(?fee) as ?avg) WHERE {
2     ?uni
3         <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.
4         ?prog
5             <http://www.example.com/ontology/university_ontology.owl#has_domain> ?name.
6             ?prog
7                 <http://www.example.com/ontology/university_ontology.owl#has_annual_fee> ?fee.
8 } GROUP BY ?name
9 ORDER BY (?avg)
10 LIMIT 1
```

Table Raw Response Pivot Table Google Chart

Filter query results Showing results from 1 to 1 of 1. Query took 0.1s, moments ago.

	name	avg
1	"Linguistics"	"16000"^^xsd:decimal

## Which Province offers most Free-of-cost Degree Programs

```

SELECT ?prov (COUNT(?degree) as ?num)
WHERE {
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.
    ?prog
    <http://www.example.com/ontology/university_ontology.owl#has_degree_name> ?degree.
    ?prog <http://www.example.com/ontology/university_ontology.owl#has_annual_fee> 0.
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_province> ?prov.
}
GROUP BY ?prov
ORDER BY DESC (?num)
LIMIT 1

```

prov	num
"Punjab"	3

## Which domain offers Degree Programs other than General

```

SELECT DISTINCT ?domain WHERE {
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.
    ?prog
    <http://www.example.com/ontology/university_ontology.owl#has_degree_type> ?degree.
    ?prog <http://www.example.com/ontology/university_ontology.owl#has_domain> ?domain
    FILTER NOT EXISTS{ ?prog
        <http://www.example.com/ontology/university_ontology.owl#has_degree_type> "General".}
}

```

domain
"Engineering"
"Computing"
"Management"

## Which degree programs have duration less than 4 years?

```

SELECT DISTINCT ?name ?dur
WHERE {
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.
    ?prog
    <http://www.example.com/ontology/university_ontology.owl#has_degree_name> ?name.
    ?prog <http://www.example.com/ontology/university_ontology.owl#has_duration> ?dur.
    FILTER (?dur < 4).
}

```

The screenshot shows a SPARQL query editor interface. On the left, there are tabs for Query 1 through Query 10, with Query 7 selected. The main area contains the SPARQL query. To the right, there are several icons for file operations (Save, Open, Copy, Paste, Run, etc.). The results are displayed in a table format:

	name	dur
1	"Bachelors of Business Administration"	"3"^^xsd:integer
2	"Bachelors of Business Administration"	"2"^^xsd:integer
3	"AD Management"	"2"^^xsd:integer
4	"AD Physics"	"2"^^xsd:integer
5	"BS Balochi"	"2"^^xsd:integer

## Which university Pioneered BS AI in Pakistan?

```

SELECT ?uni {
{SELECT DISTINCT (MIN(?year) as ?min) WHERE {
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.
    ?prog <http://www.example.com/ontology/university_ontology.owl#has_degree_name> "BS Artificial Intelligence".
    ?prog
    <http://www.example.com/ontology/university_ontology.owl#has_program_launch_year> ?year.
} }
?uni <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.
?prog <http://www.example.com/ontology/university_ontology.owl#has_degree_name> "BS Artificial Intelligence".
?prog <http://www.example.com/ontology/university_ontology.owl#has_program_launch_year> ?min.
}

```

The screenshot shows a SPARQL query editor interface. On the left, there are tabs for Query 1 through Query 11, with Query 7 selected. The main area contains the SPARQL query. To the right, there are several icons for file operations (Save, Open, Copy, Paste, Run, etc.). The results are displayed in a table format:

	uni
1	Air%20University%20-%20Islamabad
2	NUCES,%20FAST%20-%20Islamabad

## Which university Pioneered BS AI in Punjab?

```

SELECT ?uni ?min WHERE{
{SELECT (MIN(?year) as ?min) WHERE {
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.
    ?prog <http://www.example.com/ontology/university_ontology.owl#has_degree_name> "BS
Artificial Intelligence".
    <http://www.example.com/ontology/university_ontology.owl#has_program_launch_year> ?year.
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_province> "Punjab".
}}
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.
    ?prog <http://www.example.com/ontology/university_ontology.owl#has_degree_name> "BS
Artificial Intelligence".
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_province> "Punjab".
?prog <http://www.example.com/ontology/university_ontology.owl#has_program_launch_year> ?min.
}

```

uni	min
The%20Islamia%20University%20of%20Bahawalpur	"2020"^^xsd:integer

## Which degree programs cost less than Rs. 21,000?

```

SELECT ?uni ?degree ?fee{
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.
    ?prog
    <http://www.example.com/ontology/university_ontology.owl#has_degree_name> ?degree.
    ?prog
    <http://www.example.com/ontology/university_ontology.owl#has_annual_fee> ?fee.
    FILTER (?fee < 21000) }

```

uni	degree	fee
University%20of%20Kotli	'BS Artificial Intelligence'	"0"^^xsd:integer
University%20of%20Malakand	'Bachelors of Business Administration'	"0"^^xsd:integer
Mir%20Chakar%20Khan%20Rind%2	'Bachelors of Business Administration'	"0"^^xsd:integer
University%20of%20Azad%20Jamm	'Bachelors of Business Administration'	"0"^^xsd:integer
Government%20College%20Univers	'AD Management'	"0"^^xsd:integer
Government%20College%20Univers	'Bachelors of Business Administration'	"0"^^xsd:integer
University%20of%20Turbat	'BS Balochi'	"16000"^^xsd:integer
BUITMS	'BS Computer Science'	"20800"^^xsd:integer
BUITMS	'BS Telecommunications '	"20800"^^xsd:integer

## How many years has each university offered BS CS?

```

SELECT ?uni ((2023 - ?year) as ?years){
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.
    ?prog
        <http://www.example.com/ontology/university_ontology.owl#has_degree_name> "BS Computer Science".
    ?prog
        <http://www.example.com/ontology/university_ontology.owl#has_program_launch_year> ?year.
} LIMIT 5

```

The screenshot shows a SPARQL query interface with multiple tabs at the top: Query 1, Unnamed, Query 2, Query 3, Query 4, Query 5, Query 6, Query 7, Query 8, Query 9, Query 10, Query 11, Query 12, Query 13, and Query 14. The main area displays the following SPARQL query:

```

1 SELECT ?uni ((2023 - ?year) as ?years)
2 {
3     ?uni
4         <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.
5         ?prog
6             <http://www.example.com/ontology/university_ontology.owl#has_degree_name> "BS Computer Science".
7             ?prog
8                 <http://www.example.com/ontology/university_ontology.owl#has_program_launch_year> ?year.
9
10 } LIMIT 5

```

Below the query, there are several red circular icons for file operations (Save, Copy, Paste, etc.) and a red "Run" button. To the right, a table titled "Filter query results" shows the results from 1 to 5 of 5 queries. The table has columns "uni" and "years". The data is as follows:

	uni	years
1	Air%20University%20-%20Islamabad	"21"^^xsd:integer
2	NUCES,%20FAST%20-%20Islamabad	"23"^^xsd:integer
3	Lahore%20University%20of%20Management%20Scien	"29"^^xsd:integer
4	Abdul%20Wali%20Khan%20University	"14"^^xsd:integer
5	University%20of%20Sialkot	"10"^^xsd:integer

## Number of Honors degrees in each province?

```

SELECT ?prov (COUNT(?prog) as ?p){
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_province> ?prov.
    ?prov
        <http://www.example.com/ontology/university_ontology.owl#has_degree_type> "Honors".
} GROUP BY ?prov

```

The screenshot shows a SPARQL query interface with tabs for Query 14 and Query 15. The main area displays the following SPARQL query:

```

1 SELECT ?prov (COUNT(?prog) as ?p)
2 {
3     ?uni
4         <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.
5         ?uni
6             <http://www.example.com/ontology/university_ontology.owl#has_province> ?prov.
7             ?prog
8                 <http://www.example.com/ontology/university_ontology.owl#has_degree_type> "Honors".
9             } GROUP BY ?prov

```

Below the query, there are several red circular icons for file operations (Save, Copy, Paste, etc.) and a red "Run" button. To the right, a table titled "Filter query results" shows the results from 1 to 3 of 3 queries. The table has columns "prov" and "p". The data is as follows:

	prov	p
1	Punjab	"6"^^xsd:integer
2	Islamabad	"1"^^xsd:integer
3	Khyber Pakhtunkhwa	"1"^^xsd:integer

## Which domain offers most Honors programs?

```
SELECT ?dom (COUNT(?prog) as ?p){  
    ?uni <http://www.example.com/ontology/university_ontology.owl#has_program> ?prog.  
    ?prog  
<http://www.example.com/ontology/university_ontology.owl#has_degree_type> "Honors".  
    ?prog  
<http://www.example.com/ontology/university_ontology.owl#has_domain> ?dom.  
} GROUP BY ?dom
```

The screenshot shows a SPARQL query interface with the following details:

- Query 15:** The active query window contains the SPARQL code provided above.
- Results:** A table displays the results of the query. The columns are labeled "dom" and "p". There are two rows:
  - Row 1: dom = "Computing", p = 4
  - Row 2: dom = "Management", p = 4
- Toolbar:** Includes buttons for copy, paste, refresh, and run.
- Header:** Shows tabs for other queries (Query 1 through Query 14) and a "Download as" button.
- Information:** A message at the bottom says "Showing results from 1 to 2 of 2. Query took 0.1s, moments ago."

# Reflection

Building a complete formally structured ontology from scratch up till a modeled 'desktop application' helped us really test our course skills to the fullest.

It was a tough ride; having tried our best to build an error-free ontology in just a few attempts, but the tiny limitations, logical constraints and restrictions that went unnoticed made us change our solution many a times and think outside the box to cater to every detail.

We are glad to learn and be a part of the complete implementation pipeline of simple knowledge, in a non-proprietary format, being turned into a completely linked and meaningful data format that can be linked to not only add meaning to your own data but can relate to potentially any other resource that exists on the Linked Data Cloud. We are hopeful that our limited effort in the field of higher education can be enhanced by finding more links between our resources and those existing on the Web so that every time someone accesses our ontology, they can redirect their research to other potential weblinks, and pages that add value to them.

1

## Domain motivation

Researched why and how there is room for improvement in this domain

2

## Dataset creation

Created a model dataset from scratch, manually

3

## Conceptual Model

Understanding and relating how entities link with each other contextually

4

## Ontology Mapping

Mapping the ontology design into a formal structure (OWL)

5

## Querying

Running SPARQL Queries for verification

6

## Frontend

Putting it all together in an application

20