Towards an Ontology Network for Italian Educational Institutions

Luigi Asprino[1,2,*], Aldo Gangemi[1,2], David Grassi[3], Giorgia Lodi[2], Nicola Malloggi[3], Elettra Morini[3], Maria Teresa Sagri[3] and Eniko Tolvay[3]

[1]University of Bologna, Via Zamboni, 33, 40126 Bologna, Italy
[2]Istituto di Scienze e Tecnologie della Cognizione (ISTC-CNR), Via Giandomenico Romagnosi 18a, 00196, Rome, Italy
[3]Istituto Nazionale di Documentazione, Innovazione e Ricerca Educativa (INDIRE), via M. Buonarroti 10, 50122, Firenze, Italy

Abstract

The adoption of digital technologies highlighted the importance of communities of practice and monitoring systems to foster innovation. To this end, the Italian Ministry of Education and Merit (MIM) and the National Institute for Documentation, Innovation and Educational Research (INDIRE) promoted the project "Osservare la scuola". This project aims at developing a geo-located information system designed to analyse and support improvement and innovation processes in the Italian school system. The system integrates data collected by INDIRE and MIM on schools, projects and socio-economic contexts, allowing the analysis of school project behaviour and its alignment with strategic documents (RAV, PTOF, social reporting). It also serves as a strategic tool for local and national decision-making, contributing to the digital and educational transformation of the country. The data collected helps education stakeholders to identify performance indicators, promote sustainable education strategies and replicate innovations in similar contexts. This paper reports on the ongoing activity of formalisation of a collection of interconnected ontologies (School, ScholasticProject, ScholasticContext) that aim at modelling the Italian education domain and that are used to structure the collected information.

Keywords

Education, Ontology, Knowledge Extraction

1. Introduction

The continuous transformation and improvement of the educational system represent critical challenges to ensuring quality, equitable, and inclusive education [1]. Moreover, the adoption of digital technologies highlighted the importance of communities of practice and monitoring systems to foster innovation [2]. In this context, INDIRE (National Institute of Documentation, Innovation, and Educational Research) has launched the project “Osservare la scuola” to support and analyse the innovative strategies of Italian schools. This project aims to understand and foster transformation processes by collecting, analysing, and representing data, with the goal of converting episodic experimentation into sustainable and transferable models of change. The initiative is based on the use of ontologies, text mining tools, and data visualization technologies to analyse the strategic behaviours of schools, identify trends, and provide valuable insights for the design of educational policies. The project seeks to enhance research, training, and experimentation activities, promoting the dissemination of best practices and strengthening schools’ ability to address current educational challenges.

A particular contribution of the project is the development of a collection of three networked ontologies, namely School, ScholasticProject and ScholasticContext. These ontologies provide a conceptual model of the Italian educational domain and the ontological basis for modelling the collected data that flows into the Knowledge Graph of the Italian education system. These tools enable the reconstruction of innovation processes and the representation of variables characterizing schools’ strategic

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*Corresponding author.
luigi.asprino@unibo.it (L. Asprino); aldo.gangemi@unibo.it (A. Gangemi); d.grassi@indire.it (D. Grassi); giorgia.lodi@cnr.it (G. Lodi); n.malloggi@indire.it (N. Malloggi); e.morini@indire.it (E. Morini); t.sagri@indire.it (M. T. Sagri); e.tolvay@indire.it (E. Tolvay)
0000-0003-1907-0677 (L. Asprino); 0000-0001-5568-2684 (A. Gangemi); 0000-0001-6020-5874 (G. Lodi)

behaviour, providing a solid foundation for analysis and decision-making support. Notably, these resources align with and contribute to other efforts of the Italian public administration, such as OntoPiA and schema.gov.it.

This article aims to present the preliminary results of the project, focusing on the methodologies adopted, the ontologies developed, and the implications for defining innovative school models.

2. Related Work

The use of ontologies in the educational domain has been explored through various studies, each highlighting distinct applications, methodologies, and conceptual models.

A comprehensive review by Stancin et al. analyses the role of ontologies in education, highlighting their use in representing learning domains through the definition of concepts, relationships, and properties. The study reviewed 95 articles from 2015 to 2019, showing a growing trend in the use of ontologies in education. Although the study does not focus on a specific ontology, it emphasizes the importance of ontological methodologies for structuring educational data and guiding curriculum management. This study highlights the fact that ontologies in the education domain are mainly used to model curricula, describe learning domains (e.g. describing topics to be mastered by students, and the pedagogical relationships between topics), learner data (e.g. describing student learning and to extract knowledge regarding their performance), and e-learning services with little regards at the school intended as organizational entity.

Globa et al. proposes an ontology-driven approach to represent and analyse information from scientific and educational organisations in order to assess their quality of functioning. The general ontology is divided into several ontologies to represent different aspects of organisational performance. Although the ontology does not address the school domain, the modularisation of the ontology based on the modelling intentions, as adopted in our work, (i.e. representing educational characteristics and modelling quality of functioning) is beneficial for improving the modelling and reusability of the ontology.

Das et al. investigate how ontology-based approaches can address the limitations of traditional library classification systems in the educational domain. Their work focuses on the construction of the Educational Institution Ontology (EIO). The ontology enables a hierarchical organization of educational institutions, segmenting them into facets such as complexity levels (e.g., preschools, primary schools, universities) and teaching modalities (e.g., distance or in-person learning). However, this conceptual model does not fully apply for the Italian classification. This work aims at addressing this information gap by proposing a hierarchy of the Italian schools.

3. Materials

This section provides an overview of the ontology network of Italian educational institutions. The network comprises three modules: School, ScholasticProject and ScholasticContext. School focuses on describing scholastic institutions as organisations, providing a hierarchy of Italian schools and their relationships. ScholasticProject describes the projects carried out by schools to improve and innovate the education offer. ScholasticContext enables the socio-economic context in which a school is situated to be described.

3.1. School

The aim of the ontology is to provide a formal description of a school interpreted as an organization. The general design choice for this module is to name its entities in Italian. This is because they pertain to the Italian education system and a translation into another language might result in misinterpretation. Nevertheless, in order to enhance the readability of the paper, the closest English translation is provided alongside the Italian identifier given to the class. The main class enclosing

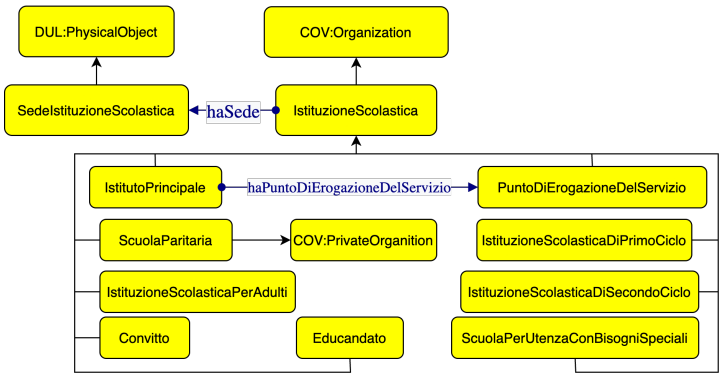

Figure 1: A diagram of the main distinctions defined in the School ontology.

all the schools is `IstituzioneScolastica` (Scholastic Institution). The classification of scholastic institutions can be approached through the lens of four distinct dimensions. The primary question to be considered is whether the school can be regarded as a hub school (`IstitutoPrincipale`) or a spoke (`PuntoDiErogazioneDelServizio`). Secondly, the question arises as to whether the school targets the first or second cycle of education (`IstituzioneScolasticaDiPrimoCiclo` or `IstituzioneScolasticaDiSecondoCiclo`). Thirdly, the question of whether the school is a private organisation (`ScuolaParitaria`). The fourth point for consideration is the question of whether the activity is intended exclusively for adults (`IstituzioneScolasticaPerAdulti`). However, there are schools that do not fall into this classification because they deal with special cases, such as "Educandato" and "Convitto". Figure 1 depicts these distinctions.

Each `IstitutoPrincipale` has one or multiple `PuntoDiErogazioneDelServizio`. This relation is implemented via the object property `haPuntoDiErogazioneDelServizio`. This property has been specialised by `haPuntoDiErogazioneDiSezioneSeraleOCarceraria` which has a restricted domain (i.e. `Liceo or IstitutoProfessionale or IstitutoTecnico`) and range (`SezioneSerale or SezioneCarceraria`).

In accordance with the regulations governing the Italian education system, class restrictions have been defined in order to implement the regulatory constraints to which each school must adhere. For example, every `IstitutoPrincipale` must have at a relation `haPuntoDiErogazioneDelServizio` with a `PuntoDiErogazioneDelServizio`. This constraint is expressed by the class restriction (in Manchester syntax).

```
haPuntoDiErogazioneDelServizio some PuntoDiErogazioneDelServizio
```

Finally, to improve the interoperability with public administration ontology we aligned the classes defined in the ontology with OntoPiA's classes. The source code of the ontology is available at the following link [1].

3.2. ScholasticProject

ScholasticProject describes the projects carried out by schools that enables to characterise the strategic behaviour of the schools. The ontology is depicted in Figure 2. As for the School ontology, ScholasticProject aligns and extends the Project Ontology of the OntoPiA suite. OntoPiA's Project is the ontology of the Italian application profile for (public) projects. ScholasticProject extends the OntoPiA's class `PublicInvestmentProject` with `ScholasticProject`, therefore inheriting all of its properties. A `ScholasticProject` is conducted by a school (i.e. `IstituzioneScolastica`) and is characterised by a scope (i.e. `ScholasticProjectScope`) and a theme (i.e. `ScholasticProjectTheme`). The

[1] https://bit.ly/3YNp2qr

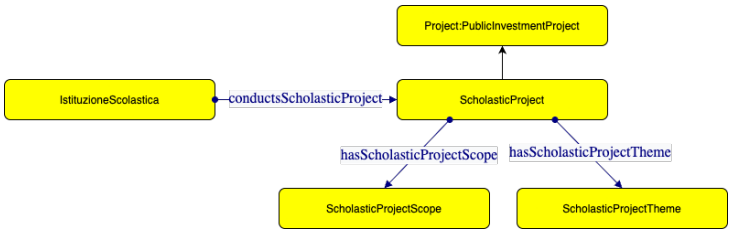

Figure 2: The ScholasticProject ontology.

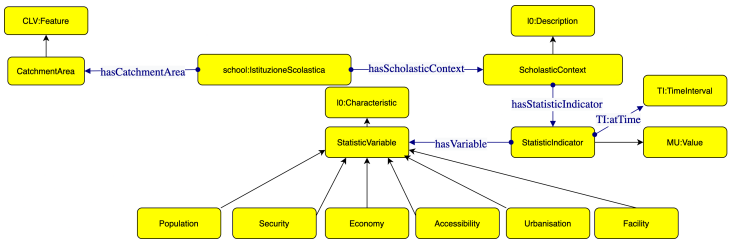

Figure 3: The ScholasticContext ontology.

scope and the theme can be considered as open vocabularies that enable a fine-grained description and classification of the project. The source code of the ontology is available at the following link[2].

3.3. ScholasticContext

The ScholasticContext module (depicted in Figure 3) allows to describe the socio-economical context in which a school is situated. The socio-economical context of a school is defined as a collection of `StatisticIndicators` where each indicator is a value of a certain `StatisticVariable` taken at a certain time. The ontology defines six classes of statistic variables matching the dimensions on which the socio-economical context of a school is to be evaluated: Population, Security, Economy, Accessibility, Urbanisation, and Facility. Finally, the ontology defines the `CatchmentArea` of a school which is the area from which the school attracts students. As for the other modules, classes defined in ScholasticContext are aligned to OntoPiA's ones. The source code of the ontology is available at the following link[3].

4. Conclusions and Future Work

The "Osservare la scuola" project has demonstrated the potential of leveraging conceptual frameworks to support the ongoing transformation of the Italian educational system. The project aims at developing interconnected ontologies (School, ScholasticProject, and ScholasticContext) and integrated them into a Knowledge Graph, thereby establishing a robust infrastructure for analysing and visualising data related to schools' strategic behaviours. The system allows to investigate how schools interpret the spaces of autonomy provided by the legislation and to understand the identities of schools in relation to the different contexts in which they are located. Its main goal is to monitor the transformation of the school system so that its findings can be used to inform the decision-making processes of policymakers at the local, regional, and national levels. The paper presented a preliminary version of the developed ontologies. It is anticipated that future directions will encompass the expansion of the ontology network and the construction of a knowledge graph, with the objective of integrating multiple data sources.

[2] https://bit.ly/43ju6Em
[3] https://bit.ly/3H2QhHo

Declaration on Generative AI

During the preparation of this paper, the authors used Generative AI tools (namely, DeepL and Grammarly) for grammar checking. After using these tools, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

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