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# A Literature Review on Research Opportunities in Ontology Alignment for Quality Standards in Higher Education

**Novita Br Ginting**
Universitas Ibn Khaldun Bogor, Indonesia

**Bazilah A. Talip**
Universiti Kuala Lumpur, Malaysia

**Siti Haryani Shaikh Ali**
Universiti Kuala Lumpur, Malaysia

**Foni Agus Setiawan**
Universitas Ibn Khaldun Bogor, Indonesia

**Rudi Hartono**
Universitas Ibn Khaldun Bogor, Indonesia

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# A Literature Review on Research Opportunities in Ontology Alignment for Quality Standards in Higher Education

**Novita Br Ginting, Bazilah A. Talip, Siti Haryani Shaikh Ali, Foni Agus Setiawan, Rudi Hartono**

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## Abstract

Higher education today operates in a globally competitive environment. Competition is increasingly focused on quality. The quality of higher education reflects the relationship of higher education with users. Higher education uses various standards in the internal quality assurance system. It makes improvements in performance, features, suitability, reliability, durability, service, responsiveness, aesthetics, and reputation to support the progress of the quality of its performance. Implementing standards requires excellent effort because it requires quality fulfillment, and the satisfaction of each standard criterion requires internal and external audit processes. Standard alignment is needed for cost efficiency in implementing standards. Standard alignment can be done with ontology alignment technology. However, before applying ontology alignment, each ontology standard is needed. This study aims to explore literature that has implemented ontology and ontology alignment in education. This study aims to find out whether there has been research on the alignment of educational quality standards. The results of this study show that ontology has been applied in education, namely on the topics of curriculum, e-learning, learning assessment, system integration, syllabus, learning style, service, and accreditation. The implementation of ontology alignment has been carried out on the topics of Profile Learning, Learning Design, E-Learning, Curriculum, and System Integration. While the application of ontology or ontology alignment on educational quality standards has yet to be found by research that discusses it, quality standards have been applied to quality management models based on ISO 9000 requirements and software quality standards based on CMMI standards.

## Introduction

Quality is the effect of a customer's view of something when they receive it (Shawyun, 2016). Quality is the fulfillment of conformity with norms and standards as expected by users (Abuhav, 2017). Higher education today operates in a globally competitive environment focused on quality (Moore, 2021; Oustous et al., 2021; Sherstobitova & Iskoskov, 2020). The quality of higher education reflects the relationship of higher education

with users (Gilbert, 2020; Institutional Care Division, 2007). The changing environment requires universities to quickly adapt to changing user demands ( Bertiz, 2017; Maddah, 2021; Vatsa, 2021; ZboRovSKa, 2020). Higher education uses various guidelines and standards in the quality assurance system to meet the quality of its products and improve performance, features, suitability, reliability, durability, service, response, aesthetics, and reputation. The government plays an active role in building an internal and external quality assurance system in universities through the accreditation process (Košir, 2021). Standards that universities, such as ISO 21001:2018, are management systems for educational organizations (Gilbert, 2020; Services, 2018). ISO 17025:2017 is the primary standard for laboratory and testing competence (Assessment, 2017). ISO/TR 11219:2012 The standard, primarily academic and public libraries, is used for libraries and applies to all countries (Evaluation, 2012).

The implementation of quality standards in universities is supportive in improving the quality of performance. Implementing this standard requires significant effort because every application of the standard will require the fulfillment of the expected quality, and ensuring the satisfaction of each standard criterion requires internal and external audit processes. The application of separate quality standards could be more efficient and requires high costs. Overcoming the problem of standard integration can be done through the standard alignment process, namely by utilizing ontology alignment technology. However, before applying ontology alignment, each standard ontology is available. This study aims to explore literature that has implemented ontology and ontology alignment in education. Through this literature excavation, it will be known what topics have applied ontology technology and ontology alignment in the field of education. I would like to know if there are opportunities to research to align quality standards in the field of education.

## Ontology

Universities have different types and structures of data and use diverse information systems in managing data and information, so they need semantic web technology to represent their data knowledge (Eremeev et al., 2022). Semantic web technologies are used in the educational domain to solve problems of integration, information sharing, web services, data reasoning, and knowledge representation from data. Knowledge representation is used to decide (Ali & Falakh, 2020). Ontology is a concept for describing a domain of knowledge (Bonacin et al., 2021). Ontology can represent knowledge and be understood by humans and machines so that knowledge can be accessed through the exchange of information between humans and heterogeneous systems(Iqbal et al., 2018).

An ontology represents knowledge using ontology web language (OWL) (Kuntarto et al., 2019). Ontology Web Language (OWL) and Resource Description Framework (RDF) are the main languages used. They are some of the semantic standards the World Wide Web Consortium (W3C) set since 2009 (Tejaswini et al., 2020). OWL is a notation and formulation representing a knowledge base (Antonios et al., 2023). OWL is concerned with defining therminologies in classes and properties (Chong & Lee, 2022). Through OWL, it is possible to define taxonomies for classes and properties, and this is due to its expressive power as a description logic (DL) language (Do et al., 2022). There are several ways to represent knowledge: 1) RDF (resource description framework), 2) OWL (ontology web language), and 3) knowledge graph (Kolli, 2018) and ontology development tools can use Protégé Application (Gonz'alez-Eras, Dos Santos, & Aguilar, 2020)

The challenge universities face today is improving the quality of education (Randahn & Niedermeier, 2017). The most challenging quality improvement of education is improving the quality of learning and teaching, research, accreditation, global collaboration, assessment, human resources, learning and teaching communities, and higher education governance and management. Solving this problem starts with using the data and information available across institutional repositories and determining what information can be shared. Exploiting big data and unstructured data requires the application of ontology technology through semantic technology. Representing data becomes very important for educators to evaluate themselves and improve their performance. So, educational ontology can be used as a solution in many aspects of education as it can address the problem of information overload (Ashour et al., 2020).

Several studies that utilize the concept of ontology in solving problems in the field of education are carried out, such as ontology EDUC8 (EDUCATE) modeling four (4) main modules in the learning domain, namely: 1. learning models, 2. learning path models, 3. business models, and 4. quality assurance models (Iatrellis et al., 2019). Based on the start of the art research conducted in 2020 by (Stancin et al., 2020) the use of ontologies in the field of education has been applied for curriculum modeling and management, ontologies for describing learning domains, ontologies for describing learner data, ontologies for describing e-learning services, and multiple ontologies for describing learning domains and learner data.

A Systematic mapping study in 2019 conducted (Tapia-Leon et al., 2018b) The application of ontology in higher education of 12% applying ontologies about academic curriculum content was used in curriculum development to map courses and resources, manage learning outcomes and model curriculum management. 15% application of ontology to e-learning. 13% applied ontology to improve academic recommendations. 12% application of ontology for educational evaluation. 17% relate to the higher education enterprise by combining the system with ontology, which can describe the institutional component with its department. 8% apply ontologies to applications to improve information retrieval. 12% use ontologies for academic data integration (Bonacin et al., 2021) Web2Touch (W2T) 2021, at the 30th IEEE WETICE conference, summarized themes on the collaborative web, semantic technologies, ontologies, knowledge engineering, linked data, and the internet. This theme is applied to topics impacting society, such as education, social inclusion, and health.

## Ontology Alignment

That existing ontology can be reused for learning new ontologies by assembling, expanding, specializing, and adapting other ontologies. Techniques that can be used to reuse ontology are mapping, alignment, fusion, ontology integration, and ontology networks (Pena & Vidal, 2020). Ontology alignment maps different models in correspondence between two ontologies to find entity commonalities. The alignment process can be automated, semi-automated, and manual, providing semantic interoperability (Ali & Khusro, 2016). Ontology alignment can solve the problem of sympathy for semantic data (Chen et al., 2019). Ontology alignment (or matching) generates mappings, or correspondences, between entities from two ontologies (Li et al., 2019).

Aligning ontologies is done to support the process of data integration or system interoperability. Ontology

alignment is used to find correspondence between different ontologies in different fields (Palmisano et al., 2006). The ontology alignment process can be done manually, requiring expert domain intervention, semi-automatic, and automated (Viana et al., 2017). The alignment of the two ontologies automatically requires no user intervention (Li et al., 2019). Align automatically or dynamically using algorithms or alignment tools (Duckham & Worboys, n.d.).

From some of the references above, it can be concluded that ontology alignment can represent knowledge of system heterogeneity or from two ontologies. Ontology alignment can support the process of data integration or system interoperability through semantic web technology. Ontology alignment systems can exploit explicit knowledge encoded in ontologies through semantic web technologies. The basic schema-based matching approach (Shvaiko & Euzenat, 2005) is pictured in Figure 1.

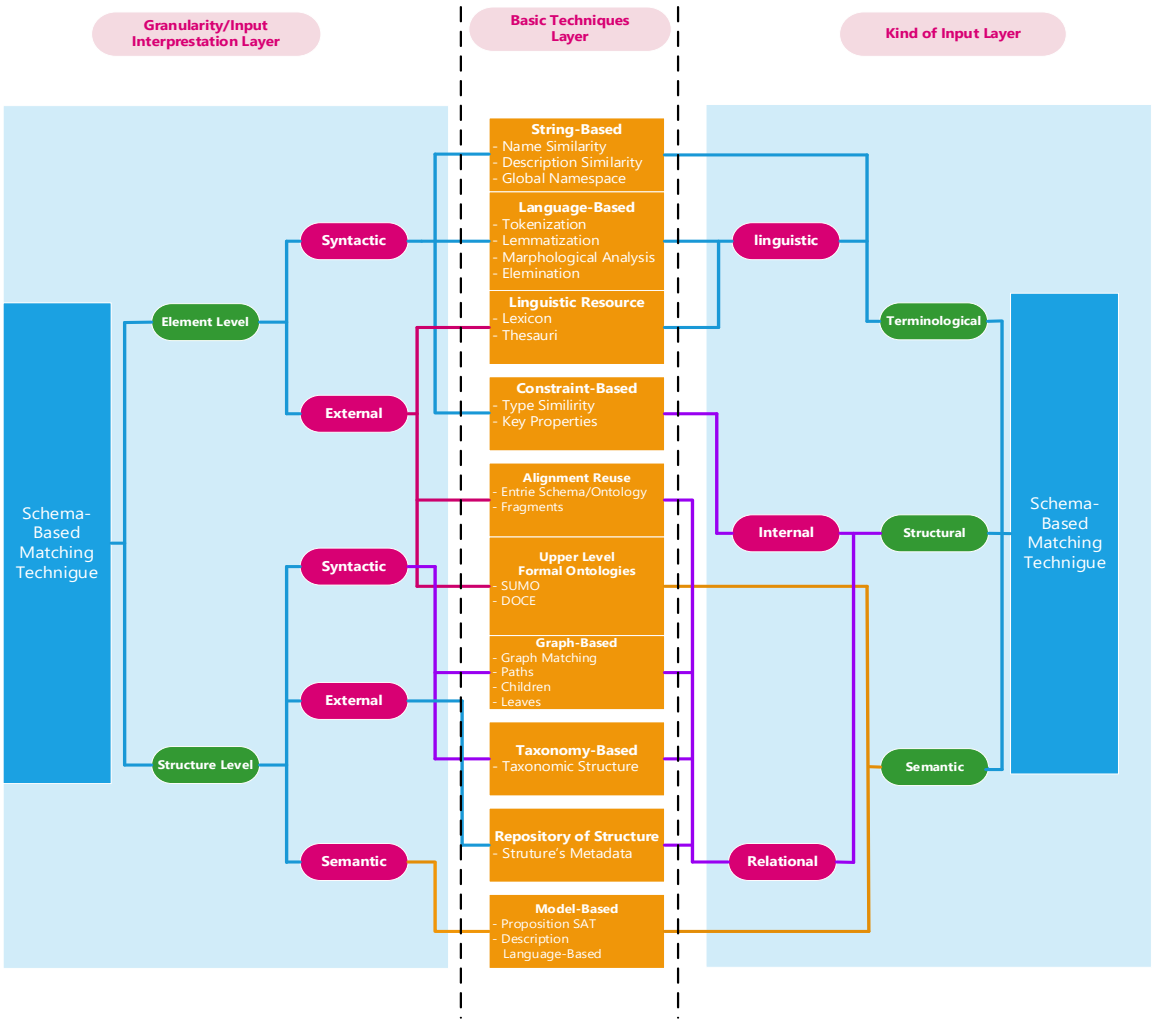


Figure 1. The Basic Schema-based Matching Approach

It is known some basic techniques in the alignment ontology process that can be done. Classify schema matching systems according to three dimensions (Shvaiko & Euzenat, 2005) as inputs, characteristics of the matching process, and outputs of the systems. Classification ontology based on dimensions is shown in Figure 2.

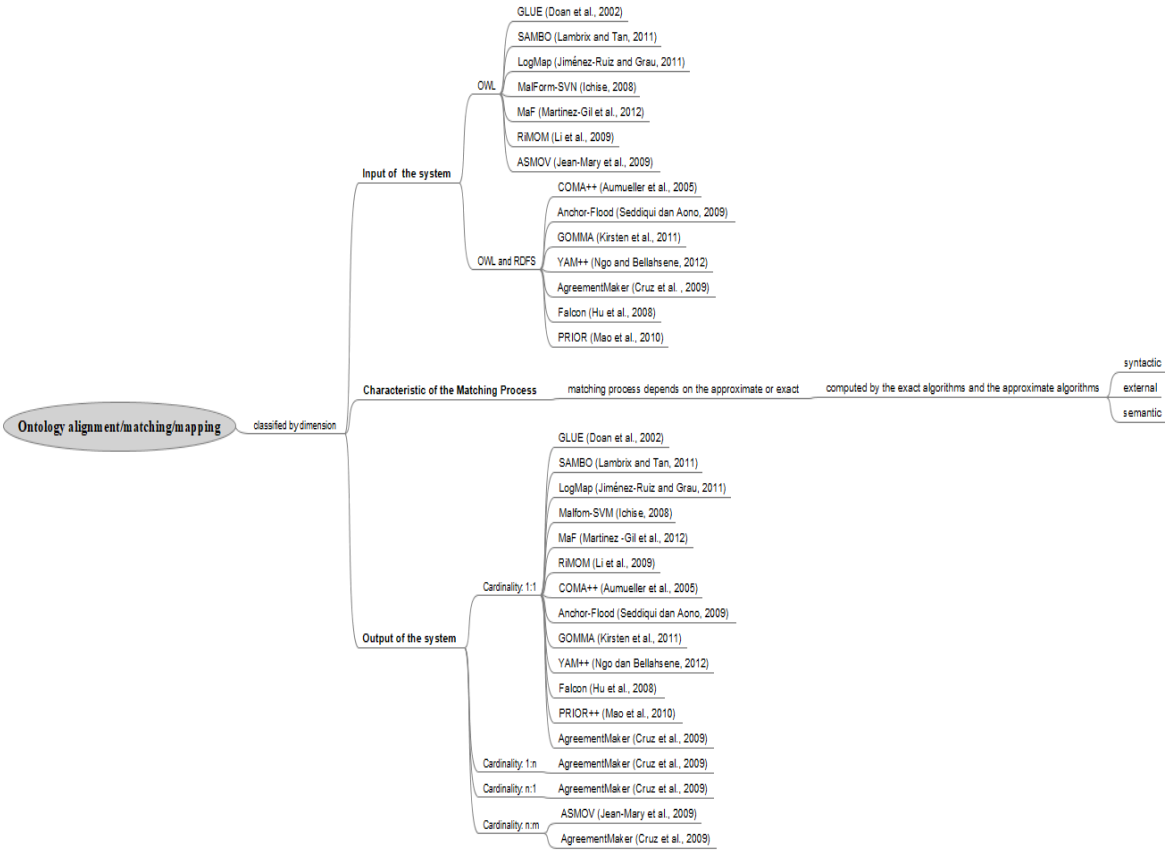


Figure 2. Schema Matching by Dimension

The ontology alignment process at the element and structure levels can be classified according to the type of input information based on 1) instance-based matching, 2) schema-based matching, 3) instance and schema-based matching, and 4) usage-based matching (Anam & Kim, n.d.; Shvaiko & Euzenat, 2013). Instance-based matching relies on instance similarity, so it is of high quality to match. Determining instance similarity, merging all instances of the ontology into virtual documents, then comparing the virtual documents using the TF/IDF similarity measure. The advantages of instance-based matching are: 1) the number of instances is higher than the number of concepts that help determine the degree of similarity of concepts, and 2) the accuracy of the match is very high.

Schema-based matching determines similarities between ontology concepts. Schema-based matching benefits Artificial Intelligence and the Semantic Web Community for multiple applications such as querying, reasoning, data integration, data mining, and knowledge discovery. Instance and schema-based matching is a generic schema and ontology matching system with simple, hybrid, and reuse-oriented matching. Usage-based matching exploits information retrieved from query logs to find correspondence between attributes in the relational schema to be matched. Classifying matching ontologies based on input information types is shown in Figure 3.

Semantic web technologies can organize and correlate data consistently and coherently because semantic web technologies have RDF schemas, OWL, and query languages such as SPARQL. However, the semantic web has many problems because of vast, incomplete, uncertain, inconsistent, and decentralized information. 10 domains are closely related to the semantic web (Patel & Jain, 2021), and their technology for overcoming these problems

is shown in Figure 4.

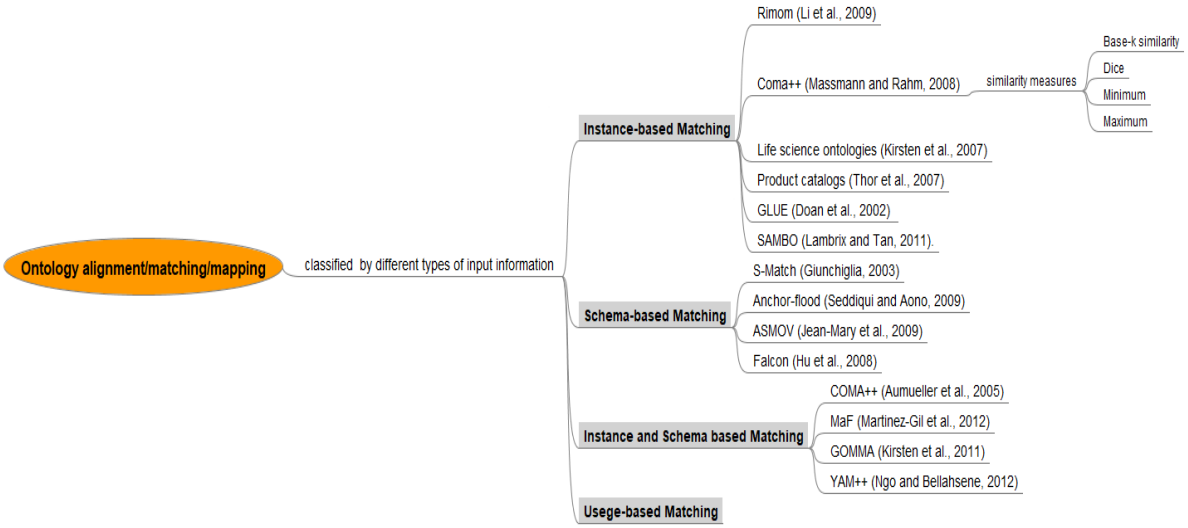


Figure 3. Classifying Matching Ontologies Based on Input Information Types

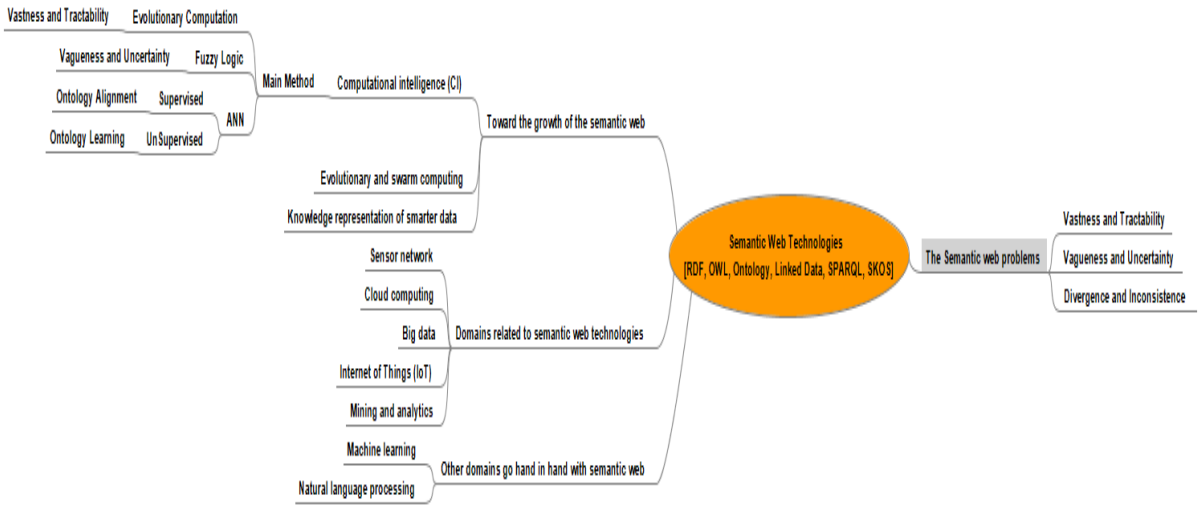


Figure 4. The Semantic Web Issues

Classify and identify relevant research lines for ontology matching; this paper shows that ontology matching can be applied to education (Otero-Cerdeira et al., 2015). Several ontology matching methods have been conducted, at least research that performs matching in solving real-life problems around practical applications in real life 10.95%. Based on these data, it is known that only a tiny part of the developed matching systems have practical applications in real-life projects. Ontology alignment can be used in geography, medicine, or agriculture. In addition, based on a survey conducted by researchers in the field of ontology alignment, they argue that ontology alignment can also be applied to the areas of information systems, e-commerce, web services, intrusion detection systems, cultural heritage, library science, government, education, banking, personal and social data management, law, and others.

## Method

This research study used the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) protocol for study selection (PRISMA, n.d.), as shown in Figure 5. Our research aims to answer the following research questions shown in Table 1.

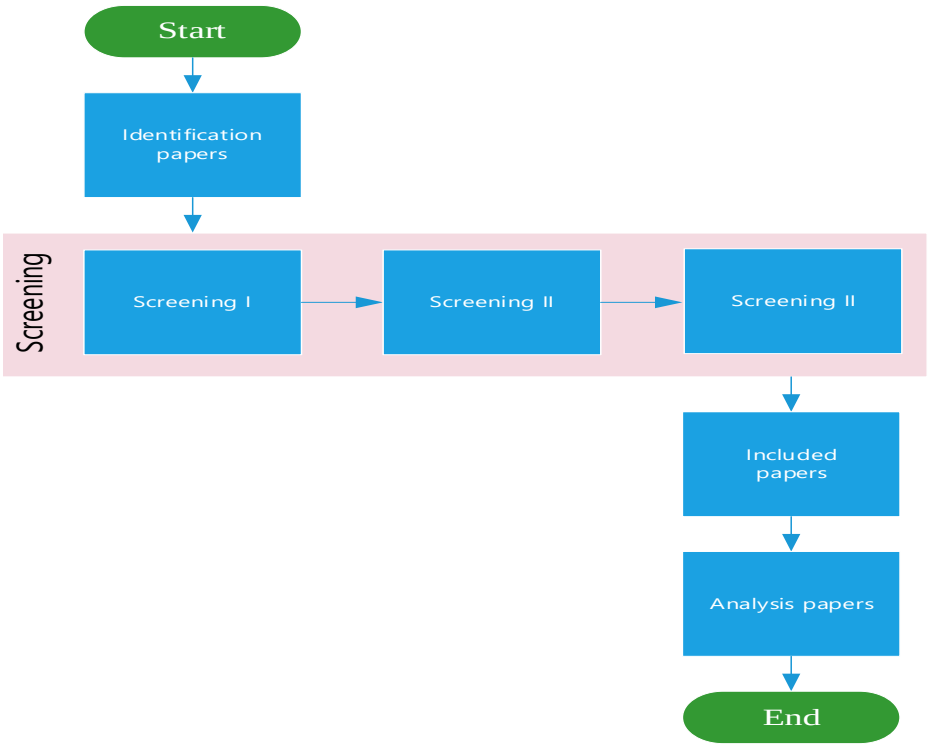


Figure 5. Stages of Research

### Identification Papers

Identification is made by establishing literature sources, study selection criteria, and study selection procedures using boolean operators AND and OR to combine terms related to "ontology" OR "ontology alignment" AND "quality assurance standard" AND "education." Data is filtered by document type (e.g., "article"), source (e.g., "journal"), and language (e.g., "English").

### Screening I

The screening I is carried out by ensuring that there are no duplicate papers, all papers are complete with abstract, and in English. All documents that do not meet this criterion will be excluded.

### Screening II

Screening II is done by reading the full abstract and keywords; if the abstract or keywords do not contain the words ontology, ontology alignment, quality assurance, or education, then the paper will be excluded.

**Screening III**

Screening III is done by reading the whole paper and ensuring that all documents have met all criteria and that the article can be fully downloaded. If the record cannot be downloaded, it will be excluded. The screening stage III will be obtained, including papers ready for analysis.

**Included Papers**

All eligible papers are obtained as references to answer research questions at this stage.

**Analysis Papers**

This stage is done by reading the whole paper more deeply analyzing and grouping papers based on research questions.

Table 1. Research Questions Literature

| Code | Research Questions | Objective |
|---|---|---|
| RQ1 | What topics are ontology applied in higher education? | This research question aims to determine what topics ontology is applied in higher education. |
| RQ2 | Is there an application of ontology to quality assurance in universities? | This research question aims to determine what educational quality standards have been applied to ontology. |
| RQ3 | What topics are ontology alignment applied in higher education? | This research question aims to determine what topics ontology alignment is applied in universities. |
| RQ4 | Is there an alignment between quality assurance ontologies in higher education? | This research question aims to determine the ontology of quality assurance standards that have been aligned. |

## Results

The process to identify, screen, and obtain eligible papers is carried out based on the stages of the research study using the PRISMA (Preferred Reporting Items for Systematic Review and Meta-analyses). The results of this process are shown in Figure 6.

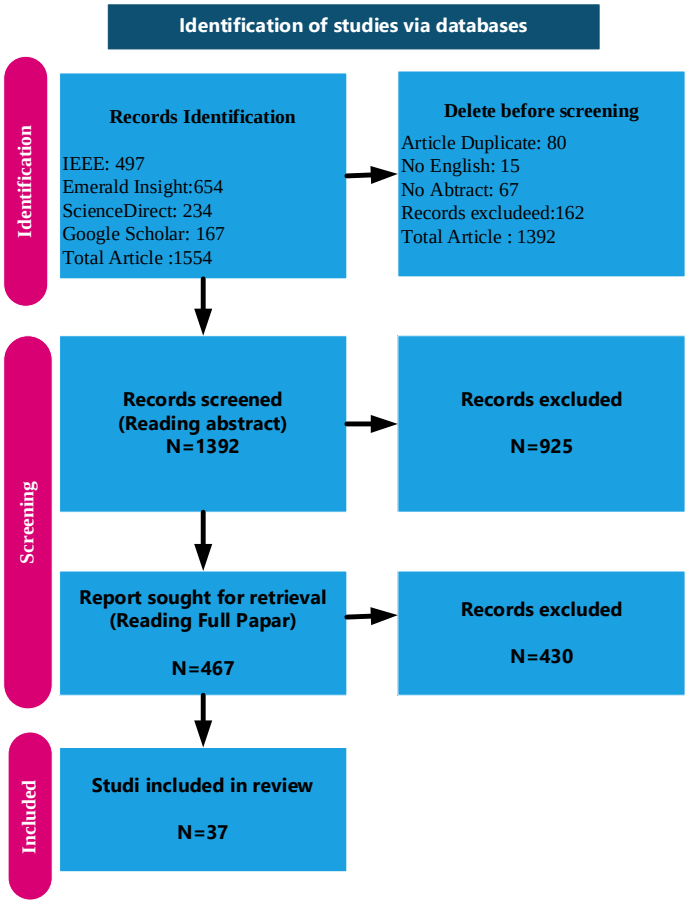


Figure 6. Process of Eligible Papers

**Identification**

Based on the research questions, a paper search was conducted using boolean operators AND and OR combined terms related to (Ontology OR ("ontology alignment" OR "ontologies alignment" OR "ontology matching" OR "ontologies matching")) AND ("higher education" OR "University" OR "College" OR "Graduate School" OR "Institute") AND ("quality assurance"). Data were filtered based on document type (e.g., "articles"), source (e.g., "journals"), language (e.g., "English"), and years (e.g., "2018 till 2023"). For research questions RQ2 and RQ3, the data is filtered by document type (e.g., "article"), source (e.g., "journal"), and language (e.g., "English"), (e.g., "2015 to 2023"). The literature sources used are IEEE, Emerald Insight, ScienceDirect, and Google Scholar. Based on the keywords used, as many as 1554 papers were obtained, with details of IEEE: 197 papers, Emerald Insight: 654 papers, ScienceDirect: 234 papers, and Google Scholar: 167 articles.

**Screening**

Screening is carried out to obtain eligible papers that will be used to answer research questions. This stage is carried out in three phases. I am screening by ensuring that no duplicate papers are checked through the Mendeley application, all articles are complete with abstract, and use English. All papers that do not meet this criterion will be excluded. The number of papers excluded at screening stage I was 162.

Furthermore, the Screening II stage is carried out by reading full abstracts and keywords. The paper will be excluded if the abstract or keywords do not contain the words ontology, ontology alignment, quality assurance, or education. The number of papers excluded at the screening stage II was 925. Furthermore, screening stage III is carried out by reading the whole paper and ensuring all documents have met all the criteria and the article can be downloaded in full. If the paper cannot be downloaded, it will be excluded. The number of papers excluded at the III screening stage was 430.

**Included**

At this stage, 37 eligible papers are obtained and ready for analysis. All suitable papers accepted are used as references to answer research questions. At this stage, reading full papers, analyzing, and classifying papers follow the research questions.

## Discussion

**RQ1: What topics are ontology applied in higher education?**

From the literature review conducted, it is known that the implementation of ontology in the field of education has been applied to the topics of e-learning at 30.43%, curriculum at 21.74%, system integration at 13.04%, learning style at 8.70%, learning assessment at 8.70%, service at 8.70%, and accreditation at 4.35%. For more details, the application of ontology in the field of education is shown in Figure 7, and the detailed papers are shown in Table 2.

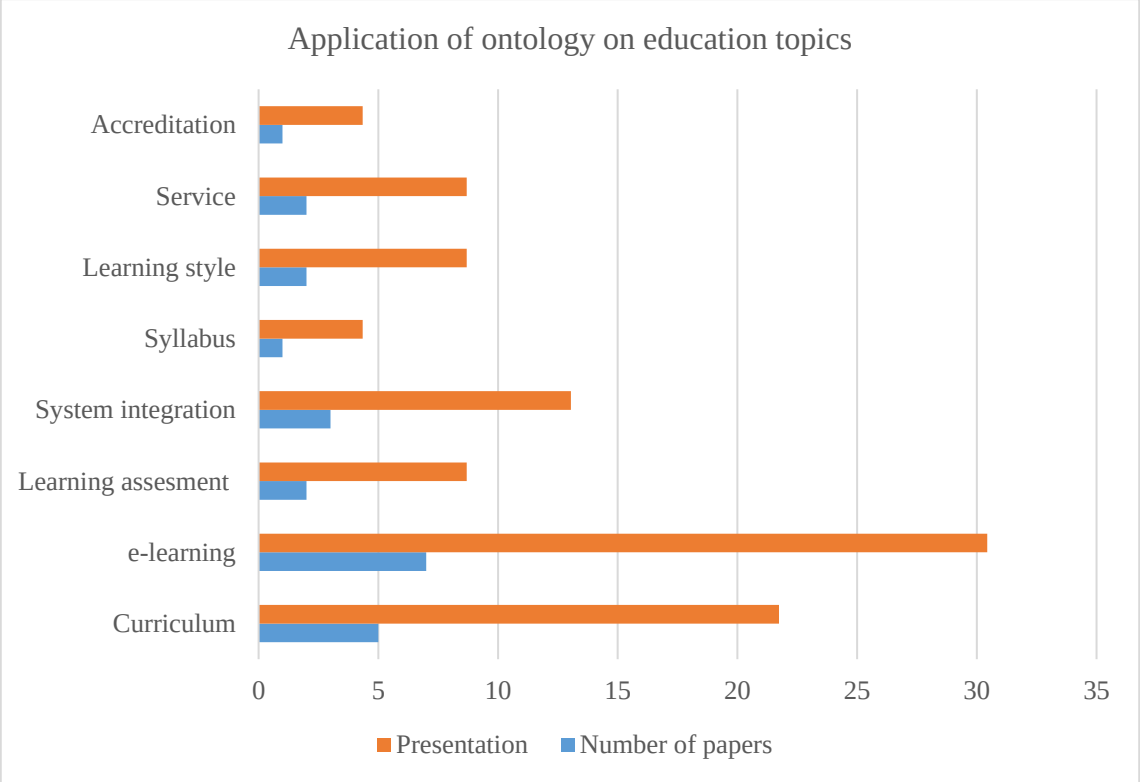


Figure 7. Application of Ontology on Education Topics

Table 2. Papers Discussing Ontology on Educational Topics

| **Topic** | **Papers** | **Description** |
|---|---|---|
| Curriculum development | (Osorio et al., 2022), (Zouri & Ferworn, 2021), (Aksenov et al., 2020), (Gasmi & Bouras, 2018), (Piedra & Caro, 2018). | They are building an ontology that can manage curriculum through mapping, alignment, and update so that it is easy to share and utilize in interoperability between universities and industry. Universities can prepare the competence of their graduates following industry needs. |
| Application of ontology technology on e-learning topics that support learning for people with disabilities. | (Khamparia et al., 2018), (Robles-Bykbaev et al., 2019), (Ingavelez-Guerra et al., 2018), (Grivokostopoulou & Paraskevas, 2019), (Hnida et al., 2018), (Assami et al., 2019), (Tzoumpa & Mitropoulos, 2020) | Ontology e-learning can support students' learning and teaching process, especially students with special needs. Ontology can analyze how students understand the material and represent user profiles. Students can use ontology e-learning based on their competence in certain materials such as mathematics, geometry, etc. Ontologies that can be used, such as e-Ucumari, CALEP, MOOCs, and GeoGebra. |
| Application of ontology technology in the student competency assessment system | (Cheniti-Belcadhi et al., 2019), (Martynov et al., 2019) | Use ontology for student competency assessment with portfolio assessment to prepare learning interactions. Ontology is also used to represent the discrepancy in assessment between the employment qualifications framework and the competencies of college graduates. |
| System Integration | (M. Ali & Falakh, 2020), (Sattar et al., 2021), (Duran & Ramirez, 2021) | Integrate educational data by utilizing the Interlocking Institutional Worlds (IWs) concept and use it for interoperability. Ontology is also integrated with educational resources in institutional repositories through semantic web development. |
| Syllabus | (Tapia-Leon et al., 2018) | Conduct a literature review of the use of ontology for syllabus representation. |
| Learning styles | (Rami et al., 2018), (Do et al., 2022) | Ontology can represent learning styles and predict them so students can adjust their learning styles to understand course material such as mathematics, algorithms, and data structures. |

| Topic | Papers | Description |
|---|---|---|
| Service | (Agus Santoso et al., 2018), (Nieto et al., 2020) | Build an ontology for ease of customer service to obtain the information they need about the college, such as study program information or information about research. |
| Accreditation | (Kovaliuk et al., 2020) | Build knowledge management concepts to build an ontology of education accreditation. Ontology can ensure the successful accreditation of study programs. |

**RQ2: Is there an application of ontology to quality assurance in universities?**

The implementation of ontology on educational quality assurance standards has yet to be found in the literature review. However, there has been research that applies ontology to quality assurance management standards based on ISO 9000, namely TOVE Quality Ontology-VB ontology (Da Silva et al., 2015). Ontology Warning Criterion Ontology (WCO) detects organizational patterns and faulty resources. Key Performance Indicator (KPI) is used to measure compliance in carrying out Standard Operating Procedure (SOP) (Hartanto et al., 2016), and Ontology for Quality Assurance Inspection (OntoQAI) for software quality standard inspection aware of CMMI assessment criteria (Kim, 1999).

**RQ3: What topics are ontology alignment applied in higher education?**

Classify and identify relevant research lines for ontology matching; this paper shows that ontology matching can be applied to education (Otero-Cerdeira et al., 2015). An overview of practical ontology alignment research in real life, especially in education, is shown in Figure 8.

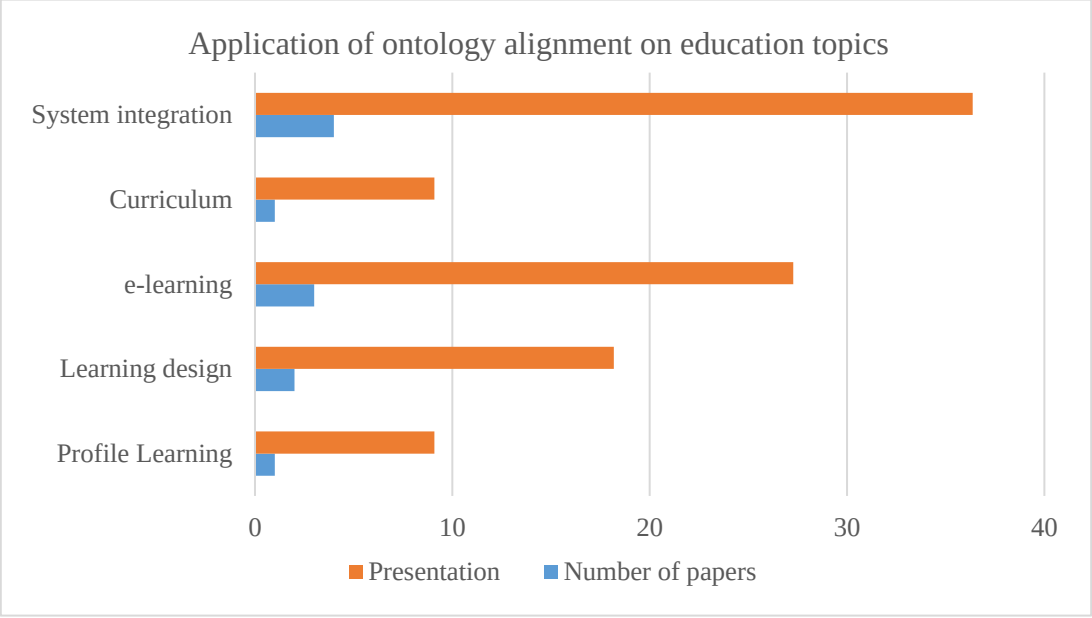


Figure 8. Application of Ontology Alignment on Education Topics

Detailed papers are shown in Table 3. The review results show that ontology alignment has been applied to system integration at 36.36%, e-learning at 27.27%, learning design at 18.18%, curriculum at 9.09%, and profile learning at 9.09%.

Table 3. Papers Discussing Ontology Alignment on Educational Topics

| **Topic** | **Papers** | **Description** |
|---|---|---|
| Profile learning | (Lmati et al., 2015) | Aligning e-orientation with ontology extended Math Bridge to direct learning of mathematics according to student profile (skills, preferences, and motivation) matching using the morphosyntactic matching technique, the resource WordNet, and the measuring structural similarity. |
| Learning design | (Koulougli & Bouzidi, 2015), (Charlton & Magoulas, 2010) | ODE (Ontology Driven engineering) as an alignment ontology. ODE adopts the concept of crowdsourcing involving a group of people (business experts, alignment experts, crowds, and experts in processing) to implement the Learning Design (LD) transformation process. |
| e-Learning | (Cerón-figueroa et al., 2017), (Paneque et al., 2023), (Ivanova et al., 2021) | Two ontologies containing Learning Objects (LOs) and Open and Distance Learning (ODL) are used for open and distance learning. The alignment process uses a binary pattern classification model and an associative model. |
| Curriculum | (Mandić, 2018) | Create an alignment ontology model to compare the informatics teacher education curriculum with the standard informatics curriculum. The matching process uses semi-automated techniques with class matching and harmonization with taxonomic categories revision bloom. |
| Integration system | (Triperina et al., 2018), (Amin, 2019), (Kahani2, 2020), (Priya & Ch., 2019) | Integrate educational ontology through an ontology alignment process to obtain an intelligent education system by applying semantic web technology. This ontology integration applies hybrid semantic similarity measure (HSSM)-based, |

| Topic | Papers | Description |
|---|---|---|
| | | multidimensional ontology-based visual ranking (MOBVR) and MCDM (multiple criteria decision-making) methods. |

**RQ4: Is there an alignment between quality assurance ontologies in higher education?**

Based on RQ1, RQ2, and RQ3, it is known that ontology has been built on quality assurance in management, compliance with the implementation of SOPs, and software quality standards. Meanwhile, research on the application of ontology or ontology alignment on educational quality standards has yet to find studies that discuss it.

## Conclusion

Based on the literature review, the application of ontology technology in education has been carried out on the topics of curriculum, e-learning, learning assessment, system integration, syllabus, learning style, service, and accreditation. The application of ontology alignment technology has also been implemented in education, especially topic profile learning, learning design, e-learning, curriculum, and system integration. At the same time, the application of ontology or the application of ontology alignment on the topic of educational quality standards has yet to be found in the literature review conducted by the author. However, the study of the application of ontology for the field of quality standards is found in the application of quality management models based on ISO 9000 requirements, compliance with the implementation of SOPs, and software quality standards based on CMMI standard assessment. Disturbing the findings of this literature study show that the opportunity to conduct a study of the application of ontology or ontology alignment on the topic of educational quality standards will be beneficial and valuable for universities if the ontology of educational standards can be built and can also be harmonized through ontology alignment, this will significantly facilitate educational institutions in improving the quality of governance.

## Recommendations

To optimize the use of information systems in universities, several opportunities for future research in the application of ontology technology or ontology alignment in the field of education are very wide open, such as building integration between information systems. Information systems based on knowledge representation strongly support top management decision-support systems. Information systems based on knowledge representation can be built by developing ontology technology or ontology alignment in education. One of the things that can be done is the application of ontology or ontology alignment on the topic of educational quality standards to optimize and streamline the process of higher education governance. In addition, ontology alignment can be used in information systems, e-commerce, web services, intrusion detection systems, cultural heritage, library science, government, education, banking, personal and social data management, and law.

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## Author Information

**Novita Br Ginting**
https://orcid.org/0000-0001-6643-4248
Universitas Ibn Khaldun Bogor
Jl. Sholeh Iskandar, RT.01/RW.10, Kedungbadak,
Kec. Tanah Sereal, Kota Bogor, Jawa Barat 16162
Indonesia
Contact e-mail: *novitawahab@uika-bogor.ac.id*

**Bazilah A. Talip**
https://orcid.org/0000-0001-5957-4066
Universiti Kuala Lumpur
1016, Jln Sultan Ismail, Bandar Wawasan, 50250
Kuala Lumpur, Wilayah Persekutuan Kuala Lumpur
Malaysia

**Siti Haryani Shaikh Ali**
https://orcid.org/0000-0001-9674-4757
Universiti Kuala Lumpur
1016, Jln Sultan Ismail, Bandar Wawasan, 50250
Kuala Lumpur, Wilayah Persekutuan Kuala Lumpur
Malaysia

**Foni Agus Setiawan**
https://orcid.org/0000-0002-4113-1280
Universitas Ibn Khaldun Bogor
Jl. Sholeh Iskandar, RT.01/RW.10, Kedungbadak,
Kec. Tanah Sereal, Kota Bogor, Jawa Barat 16162
Indonesia

**Rudi Hartono**
https://orcid.org/0000-0002-3013-0178
Universitas Ibn Khaldun Bogor
Jl. Sholeh Iskandar, RT.01/RW.10, Kedungbadak,
Kec. Tanah Sereal, Kota Bogor, Jawa Barat 16162
Indonesia