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Semantic Web Ontology for Vocational Education Self-Evaluation System

Muhamad Ali
Doctoral Student at Technical and Vocational Education
Graduate School
Universitas Negeri Yogyakarta, Indonesia
muhal@uny.ac.id

Faiq Miftakhul Falakh
Computational Logic Group
Faculty of Computer Science
Technische Universität Dresden, Germany
faiq_miftakhul.falakh@tu-dresden.de

***Abstract*—Self-evaluation is one of the most important activities undertaken by vocational high schools to improve internal and external conditions related to the performance and preparation of future work programs. In practice, self-evaluation always requires much data relating to the school. One issue that was released was that the data needed was still scattered on separate systems. Various methods are used to integrate manual and computer-aided, but it is very troublesome and requires a long time. One way to overcome this problem is to develop a self-assessment system using semantic web technology, correctly, ontology from related data. This paper aims to develop VISION, a semantic web-based ontology to improve vocational education self-evaluation systems. The method used is system development, which consists of 5 stages, namely 1) analysis, 2) design, 3) development, 4) implementation and 5) evaluation. This paper focuses on analyzing, designing, and developing a prototype of a self-evaluation system for Vocational Schools based on semantic web ontology. The results show that the concept of web semantic technology can improve the effectiveness and efficiency of self-evaluation in vocational schools in Indonesia.**

Keywords—ontology, self-evaluation, vocational high school

I. INTRODUCTION

School self-evaluation has been central to school improvement efforts in many education systems in many countries [1]. In some contexts, school self-evaluation systems are mandated through government policy; in others, each school is left to develop their approaches to carrying out the process. There are many models, frameworks, and definitions related to the self-evaluation process. The forms of evaluations carried out by each school can be different but, in principle, complement assessments in general at the micro-level and assessments at the macro level.

Self-evaluation has many terms in various countries, such as self-inquiry, self-review, audit, self-review, and self-assessment [2]. Self-evaluation is a process of reflection on practices that systematically and transparently enhance professional education and learning organizations [3]. Staff members in schools reflect practice and identify areas of action to stimulate improvement in student learning fields. Self-evaluation is carried out to ensure quality and improve educational institutions' performance in developing excellent programs [9].

Vocational High Schools have a strategic role in promoting national economic growth—vocational schools designed to produce graduates ready to work in industry or become independent entrepreneurs. The main problem in developing vocational schools is the lack of optimal self-evaluation to measure schools' real profile and condition related to strengths, weaknesses, opportunities, and threats [4, 10]. This condition has an impact on the difficulty of developing excellent programs. On the other hand, the government will find it challenging to map each vocational school's strengths and weaknesses due to the lack of information that can be accessed quickly and accurately.

In many cases, data for self-evaluation generally scattered in various sources of subsystems in schools. The data includes curriculum, students, teachers, education personnel, learning processes, facilities and infrastructure, assessment, management, administration, and others stored in separate information systems in a vocational school. Generally, vocational schools do not have an integrated system for managing scattered data. It results in data collection done manually. To overcome this problem, Ali [8, 10] has developed a vocational school self-evaluation system (SEMIS), but in its implementation, it requires a lot of classifying, aggregating, sorting, and analyzing data spread across a variety of different systems. Data in schools such as curriculum, students, graduates, learning plans, learning processes, student grades, facilities and infrastructure, administration, collaboration with stakeholders, and other data spread on different systems. It makes the implementation of self-evaluation in vocational schools hampered. To answer this challenge, we build a semantic web-based system whose primary purpose is to facilitate integration and ease the data gathering. An essential prerequisite for this integration is the availability of a global data scheme from the heterogeneous subsystems mentioned above, which is called an ontology.

Research related to web semantic technology in the field of education has been developed, such as in higher education [15], social networks [13], research [11], academic management [9,10], and quality assurance [12]. The ontology-based approach to educational evaluation is studied in several existing works [3, 5]. However, in self-evaluation in vocational high schools, there are different problems with comprehensive data coverage. As a developing country, Indonesia has more than 17,000 vocational schools spread across the archipelago [9]. In vocational schools, self-evaluation is done periodically to provide accurate information about the schools' internal conditions for future mapping and development. In this case, we have not yet discovered the concept of web semantic technology for self-evaluation of vocational high schools. This paper aims to develop VISION, a semantic web-based ontology to improve vocational education self-evaluation systems. This article focuses on ontology development, which can be applied to vocational schools in Indonesia.

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II. Self Evaluation System in Vocational Education

A. Self-Evaluation Concept

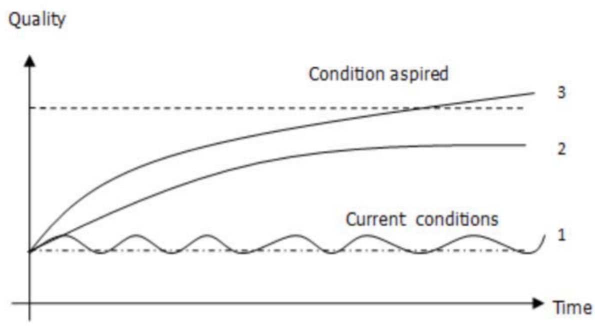
Evaluation is one of the keys to the strategy of improving the quality of education. Each program and activity must be evaluated to see success and improvement in the future. School Self Evaluation can be considered a mirror to see the school's overall internal and external conditions. Implementation of self-evaluation in schools can be interpreted merely as a way of looking systematically at how teachers teach and how students learn and make decisions about what schools want to improve [6]. Self-evaluation is the process of producing change and improvement based on professional reflection, challenges, and support among practitioners [7].

The definition of evaluation, according to experts, is, in principle, complementary. Evaluation is the process for determining the degree to which these behavior changes are taking place [4]. It means that evaluation is the process of determining the degree of change in behavior that occurs. This understanding is closely related to the term measurement, which means that it is part of an evaluation. Evaluation is defined as a systematic process of collecting and analyzing data to determine whether, and to what degree, objectives have been or achieved; (2) evaluation is a systematic process of collecting and analyzing data to make a decision [4, 5].

School self-evaluation must be carried out by involving all school members, including school managers, teachers, education staff, students, and other related stakeholders—the principal acts as the person in charge and the teacher as the implementer. Self-evaluation must be an awareness of the school as an ongoing process to improve the quality of education [8]. Schools have a responsibility to stakeholders to provide convincing evidence about the school's success and future program plans.

Continuous improvement is a must for modern organizations in efforts to improve quality. It requires a periodic thorough self-evaluation of available resources, processes carried out, results obtained, and other related matters. Thus the significance of an organization can be measured, and there may be things that are not in line with the vision of the organization that can be directly known early on for further improvement [9]. The self-evaluation results were published to related parties expected to increase stakeholder participation in improving the quality of education. Vocational school self-evaluation is an integral part of the education unit development process. The institution's level of maturity can be tracked from the results of self-evaluation over a specified period. This document will be beneficial for future leaders, especially in improving the quality of education units. The self-evaluation process carried out and adequately controlled can find the actual profile so that it can carry out appropriate planning and actions to achieve the goals.

The process of self-evaluation planned, executed, and appropriately controlled can find the actual profile of an organization so that it can perform planning and appropriate action to achieve the aspired goals. The development organization that plans to use the self-evaluation that does not use self-evaluation can be shown in Figure 1 [7].



Explanation

1. Vocational School without self-evaluation
2. Self-evaluation without external support
3. Self-evaluation with external support

Fig. 1. Illustration of vocational school development

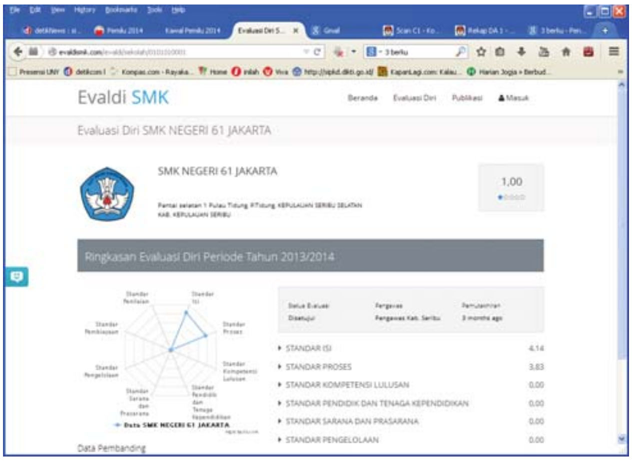


Fig. 2. Vocational Self-Self Evaluation System [8]

B. Web-Based Vocational Schools Self-Evaluation

The web-based Vocational school self-evaluation system was developed by M. Ali et al. in 2008 and refined in 2013 [9]. This system can provide facilities for schools to conduct self-evaluations online. The aspects assessed include:

1. Content standards
2. Process standards
3. Graduates' competency standards
4. Standards of educators and education staffs
5. Standards of Facilities and Infrastructure
6. Assessment Standards
7. Funding Standards

The following is a display of a self-evaluation system developed in 2013.

III. Semantic Web Ontology In Vocational High School

Vocational high schools are educational institutions that aim to prepare graduates to be ready to enter the workforce. To improve quality, vocational high schools periodically conduct evaluations, both internally and externally. Evaluation activities were carried out annually, and the

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results reported to the directorate of the development of vocational school [9]. The purpose of the vocational high school self-evaluation is to analyze internal and external conditions related to strengths, weaknesses, opportunities, and threats. Vocational high school self-evaluation also intended to prepare accreditation by the national school/madrasa accreditation body (BAN-SM).

Internal schools' self-evaluation in vocational high schools is carried out and accompanied by school supervisors to determine the appropriate parameters and criteria. School performance, which includes eight standards, is evaluated through questions and questionnaire statements filled out by the school with physical evidence. The components of school self-evaluation include 1) content standards, 2) process standards, 3) educator and education staff standards, 4) facilities and infrastructure standards, 5) graduate competency standards, 6) management standards, 7) funding standards, and 8) assessment standards [10].

In general, school data managed by academic information systems (SIAKAD). However, many data managed separately, either web-based or manual. There are several systems related to evaluation in vocational high schools in general, namely:

- Admission System
  This system manages applicant data to schools and the capacity of each expertise program. Data management is carried out centrally by the provincial education office. Every school has the authority to access new student admission data related to applicant data, school origin, number of applicants per expertise program, and the lowest grade.
- Students Data
  Schools manage this data and are regularly reported in the National Education Data Base System (DAPODIK). These data include personal data, parents, academic data, and other student data. Student data generally managed by schools with a local database system.
- Educators and Education Staff Data
  This data contains teachers and education staff's personal information, which includes academics, expertise, courses taught, training, certificates, and their experience. It managed by the school with an integrated system of other academic data using the school's academic information system
- Learning Process Data
  Some schools have implemented e-learning and stored the data on the webserver. This data is separate from SIAKAD, so it is necessary to sort, combine, and analyze appropriately for self-evaluation.
- Assessment of Data
  Assessment data are generally carried out by each teacher and separate from academic data. Although some schools integrate these data into SIAKAD, it takes hard work from schools.
- Industrial Work Practice Data
  This data is generally managed by teachers who are given the task of guiding students and are not integrated. Evaluation related to this data requires hard work and a long time to get comprehensive data.
- Infrastructure Data
  Infrastructure data generally managed by the school in a manual or computer-based system. This data includes school building data, classrooms, laboratories, practical equipment, learning media, and other infrastructure data. Infrastructure data is usually not integrated with SIAKAD, so it takes a long time to integrate into school self-evaluation.
- Schools Activities
  School activities data are generally incidental and not integrated with SIAKAD. An ad hoc committee manages these data that deals with each activity. Although there are reports of each activity, it takes a long time to integrate into the school self-evaluation
- Tracer Study
  This data is generally separate from SIAKAD and managed by an ad hoc committee. Alumni data is needed to support the accreditation process and placement of student practice in the industry. To access this data in an integrated manner with other academic data certainly requires a long time and hard work. This data is generally separate from SIAKAD and managed by an Adhoc committee. Alumni data is needed to support the accreditation process and placement of student practice in the industry. To access this data in an integrated manner with other academic data certainly requires a long time and hard work.
- Others Data
  There is still much data in schools that are not integrated with SIAKAD and are managed by each activity's ad hoc committee. Student achievement data, teacher assessment, and other incidental data need to be analyzed to produce comprehensive school self-evaluation information.

The data above are generally independent and separate either manually in notebooks, computer stands alone, or web-based systems. Most of the data management is done manually and partly with a spreadsheet file (such as Microsoft Excel), and a small portion stored on the network (admission of new students and e-learning). The process of integration of scattered data like this is complicated in doing integration for self-evaluation. The self-evaluation procedure carried out by giving questions relating to 8 standards resulted in schools' difficulty in answering and including the evidence. This self-evaluation process takes a long time, even though the web-based system.

IV. METHOD

Developing the Semantic Web Ontology for Vocational schools Self-Evaluation System was done by research and development approach. The development stages follow the ADDIE model, which consists of five steps: 1) analysis, 2) design, 3) development, 4) implementation, and evaluation. In this paper, the implementation of activities is still at the stage of analysis, design, and development. This paper only discusses the stages of analysis, design, and development of a self-evaluation vocational high school technology system based on the semantic web. The Semantic Web Ontology for Vocational schools Self-Evaluation System developed from a web-based vocational high school (SEMIS) self-evaluation system [10].

Need analysis is done through the literature study on science, standards, regulations, and rule of thumb relating to quality management and school self-evaluation. Data analysis was also carried out through observation of the condition of vocational high schools in Indonesia. Meanwhile, interviews were conducted with parties related to

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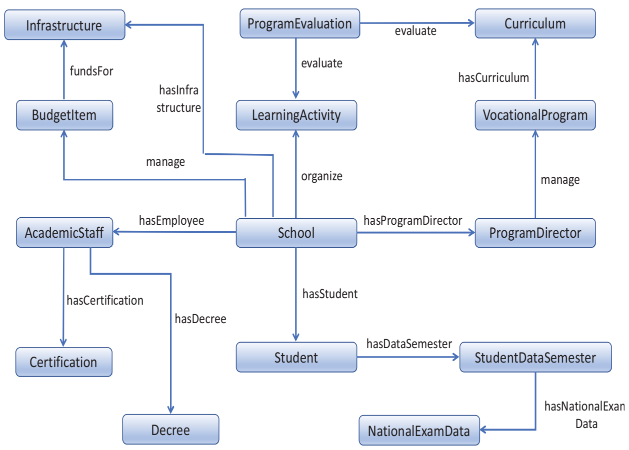

Fig. 3. The overview of the VISION ontology.

vocational school self-evaluation. The research subject is the directorate of vocational guidance, education service staff, school supervisors, school management, teachers, students, and academics who are in charge of self-evaluation of vocational schools.

The results of the analysis were used to design a vocational high school self-evaluation system following needs. The design includes databases and semantic web technology development needs. The design results manifested in a prototype system that describes the overall vocational high school self-evaluation system.

This paper only addresses the analysis, design, and prototype development stages. Implementation and evaluation steps will be carried out in the future, given the breadth of this topic.

V. RESULT AND DISCUSSION

A. VISION - VOCATIONAL EDUCATION SELF EVALUATION ONTOLOGY

This section introduces our central result, VISION, a semantic web ontology for vocational education self-evaluation system. The ontology contains 36 main classes, 34 main object properties, and seven initial datatype properties. In terms of expressivity, VISION ontology is lightweight and not very expressive. The vocabularies of the classes and properties are easy to understand, even for novice users and stakeholders. These classes and properties can easily be extended for any additional requirements in the future. The ontology is expected to answer the set of questions in the self-evaluation instrument. Figure 4. shows snippets of some parts of the ontology.

The development of the ontology follows the traditional waterfall methodology in ontology engineering [14]. The main stages are domain analysis, conceptualization, and implementation. In the domain analysis stage, we study the motivating scenarios and possible competency questions answered by the ontology. We collect all possible terms and vocabularies as candidates for the classes and properties in the ontology. This stage's primary sources are the running web-based system of self-evaluation and the official documents for self-evaluation.

The conceptualization is the design stage of the ontology. From the vocabularies, we refine the crucial concepts to obtain the main classes. We also analyze the relationship between concepts to draw potential object properties and data properties. In the last stage, we implement the ontology in OWL (Web Ontology Language), a W3C standard language to support data interoperability and reasoning between machines [16].

We classify the classes in ontology into three categories: asset, agent, and program. The asset includes all infrastructures and resources belong to a vocational high school such as Building, Classroom, Machinery, Laboratory, Library, and Book. It also covers intangible resources such as Funding, Budget, and tuition fee. The agent is an active human or body who manage or use the resources in the asset. It includes Teacher, ProgramDirector, HeadOfSchool, Student, Alumnae, Government, and Committee. The program describes processes or activities conducted by the agent on a specific period using the available assets. Some examples of classes under this category are LearningActivity, Supervision, Counseling, LecturePlanning, and Internship.

We also define the object properties of the ontology to show the relationship between classes. In a simple term, we might consider an object property as a predicate connecting two individuals belong to concepts or classes. For instance, in Fig. 1 we see an object property called "*manage*" as a label of the directed arrow between class ProgramDirector and VocationalProgram. In a simple sentence, we might read those relationships as "A Program Director *manages* A Vocational Program."

The implementation, we declare two classes connected by an object property as a domain and as a range. From the sentence example above, we define class ProgramDirector as a domain of object property *manage* and VocationalProgram as its range. Both definitions restrict which kind of individuals are permissible for being connected by the object property *manage*r. Other than object properties, we also define datatype properties that serve a similar objective to show the relationship between entities. The type of the domain of data property is classified as well, but the type of range is now literal, e.g., integer, string, Boolean, decimal, etcetera. Suppose "hasAmount" is a datatype property with the range is "xsd:integer", then it is possible to assert tuple vis:budget_item1 vis:hasAmount "15000000". This tuple represents that individual budget_item1 has a recorded amount of 15000000. For the intention of simplicity, Fig. 1 does not show all elements of the ontology.

B. EXAMPLE SCENARIOS

This section shows some possible scenarios for obtaining the desirable answers from the ontology based on the questionnaire in the self-evaluation instrument. The self-evaluation instrument is an official document released by BAN-SM (National Accreditation Institution for School and Madrasah), Ministry of Education and Culture, Republic of Indonesia. The document contains a set of questions for evaluating various aspects related to a school institution. The aspects cover assets, people, management, and vocational education program.

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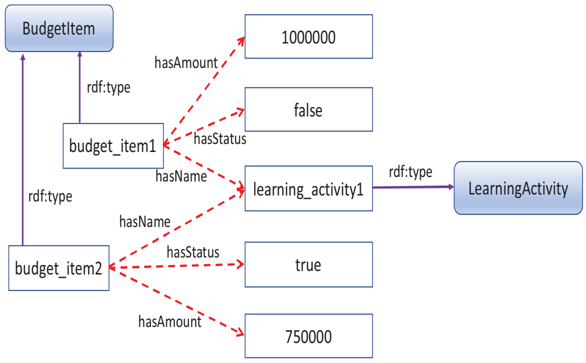

Fig. 4. A sub-ontology to answer a SPARQL query based on question no. 144.

We refer to the question sets to evaluate the ontology. First, we construct a query in SPARQL query language based on a particular question in the instrument. Then, we run the query in the local SPARQL Endpoint. Finally, we obtain the result of the query. The generated results represent the answers to the self-evaluation questions.

For the example scenarios, we populate the ontology with individual instances and their associated datatype values and descriptions. In the following, we first show the sample questions from the self-evaluation instrument, the related SPARQL queries, some parts of ontology that would answer the questions, and finally, the queries' results.

1. The actual cost percentage of the budget

The statement (or a question) no. 144 of the self-evaluation instruments mention, "School or Madrasah spent cost supporting the learning activities within three years' timeframe". The human assessor then would grade this aspect as 'A' if the school spent 76% - 100% from the allocated budget, 'B' if for 51% - 75% spending, 'C' for 26% - 50% spending, 'D' for 1% - 25% spending, and 'E' if the school did not spend the money at all.

That question is represented as a SPARQL query as following.

```
SELECT (SUM(?cost)/SUM(?budget)*100 as ?percentage)
WHERE{
{
    SELECT ?budget WHERE {
        ?budget_item vis:hasAmount ?budget;
        vis:hasName vis:la1;
        vis:hasStatus "false"^^xsd:boolean.
        }
    }
{
    SELECT ?cost WHERE {
        ?budget_item vis:hasAmount ?cost;
        vis:hasName vis:la1;
        vis:hasStatus "true"^^xsd:boolean.
        }
    }
}
```

Now the parts of the ontology which answer the above query are shown in Fig. 4.

The Fig 4 has the Status False, which means the budget item is still on the estimation plan and has not been spent yet. Otherwise, the status "true" shows the realization of the allocated budget item. Given the ontology, the SPARQL query results "75" ^^xsd: decimal, which represents the percentage of the real spending of the budget, i.e., 75%. The self-evaluation web-based system and can automatically generate the grade of this particular question as 'B'.

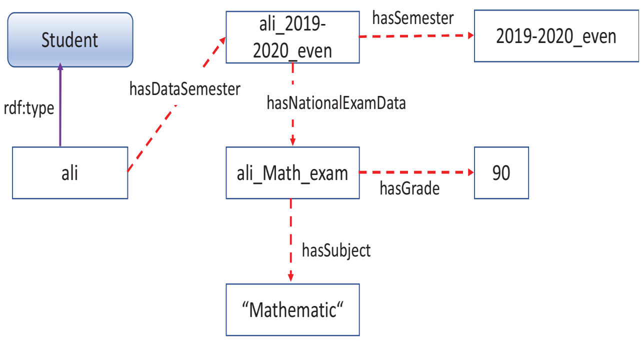

Fig. 5. A sub-ontology to answer a SPARQL Query.

2. The average grade of the National Exam (UN)

From the question no. 58 in the self-evaluation instrument. It says, "Vocational program has an achievement shown by the average grades of the National Exam in the Mathematic subject". If the average grade is equal or more than 2.0 points higher than the national average, the assessor will mark this question as 'A'. If the average is between 1.01-1.99 points higher than the national average, the mark will be 'B'. Mark 'C' for between 0.01-1.00 points higher, 'D' for equal grades compare to the national average, and 'E' if the school average is lower than the national average, particularly for Mathematic subject.

Below is the representation of the earlier self-evaluation questions in the SPARQL query.

```
SELECT (AVG(?grade) as ?average)
WHERE{
    ?student vis:hasDataSemester ?data_semester.
    ?data_semester vis:hasNationalExamData ?exam_data;
                        vis:hasSemester "2019-2020-
                        even"^^xsd:string.
        ?exam_data vis:hasCourse "Math"^^xsd:string;
            vis:hasGrade ?grade.
}
```

In the following, we show the parts of the ontology that answer the above query.

The query computes the average grade of all individuals under class Students with the conditions in terms of semester data and the national exam subject. After the completion of populating the ontology with individuals and their related data, we obtain the query result is 82. If the national average grade is 80, then the system automatically decides that the answer to this question is 'A'.

3. Decree and certification status of the vocational program director.

For the third example, we chose question no. 73, in the self-evaluation instrument. It mentions, "The director of the vocational program is a teacher who has a teaching certification and an official decree as the vocational program director. The answer to this question depends on the possession of the requirements above. We answer 'A' if all

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TABLE I. THE RESULT OF THE SPARQL QUERY BASED-ON QUESTION NO. 73

name	status	certificate_desc	decree_desc
"Putra Pratama" ^^ xsd: string	"teacher" ^^ xsd: string	"teaching_certificate" ^^xsd: string	"Electrical Engineering Program Director" ^^ xsd: string

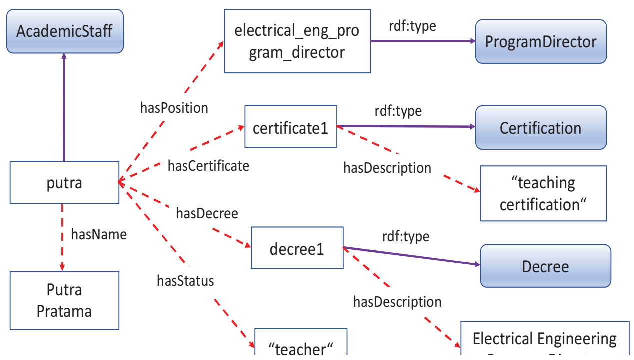

Fig. 7. A sub-ontology to answer a SPARQL query based on question no. 73.

requirements are satisfied and 'B' if he is a teacher and has a degree, but no teaching certification. We pick 'C' if he teaches and possesses a certification but no official decree letter. 'D' for only having the decree as the director, and 'E' if he does not fulfill all of the requirements.

The SPARQL query for the above question is as follows.

```
SELECT ?name ?status ?certificate_desc ?decree_desc
WHERE{
    ?staff rdf:type vis:AcademicStaff;
          vis:hasPosition ?position;
          vis:hasName ?name;
          vis:hasStatus ?status;
          vis:hasCertificate ?certificate;
          vis:hasDecree ?decree.
    ?position rdf:type vis:ProgramDirector.
    ?certificate vis:hasDescription ?certificate_desc.
    ?decree vis:hasDescription ?decree_desc.
}
```

Suppose we have the data as depicted in Fig. 7, the query result will be shown as the following table in the SPARQL Endpoint. Table I shows a row as a result of the SPARQL query. We obtain the individual name "Putra Pratama" as a teacher who has a teaching certificate and a decree as a Program Director for Electrical Engineering Program. From this result, the system will automatically conclude that the answer to question no. 73 would be 'A'.

VI. CONCLUSION AND FUTURE WORK

This paper has presented and discussed a semantic web-based ontology for vocational high school self-evaluation system. This conceptual construction regards vocational high schools as organizations and entities that include educators, education staff, students, learning processes, activities, assessments, tracer studies, infrastructure, and finance.

Based on design and development results, the self-evaluation system of vocational high school technology based on web semantics has many advantages in integrating various separate and scattered data in various systems, both manual and computer-based. With semantic ontology, the web can parse various data in the system to become an integrated system. The semantic web technology is very suitable to integrate the data of educational institutions, primarily vocational high schools, which are mostly scattered in various systems. From ontology adoption scenarios, different data from various systems can be represented and retrieved via SPARQL queries. Thus, ontology can be applied to the Semantic Web-based Academic Evaluation system. Besides, we can visualize data sets into multi-year information using timeline visualization, for example. In essence, knowledge comes from various data sources; we would like to populate the ontology with real data from different systems in the future.

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