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DEVELOPMENT OF ONTOLOGY FOR RUBRIC ASSESSMENT USING METHONTOLOGY

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ABSTRACT

In a variety of fields, including management, medicine, business, education, and others, sophisticated technology that facilitates access to relevant data is essential for supporting decision-making and resolving challenging issues. The absence of explicit representation of knowledge and data modelling through standards like RDF and OWL continues to plague the rubric evaluation sector and hinder the effective sharing between expert and general users. In order to properly characterize important aspects and norms, covering the characteristic of rubric and knowledge of psychomotor skills level, this article presents the ontology known as Psychomotor Learning Domain (PLD) ontology. Creating and developing an ontology model for rubric assessment is the goal. There are several ways to construct ontologies. A well-defined and organized methodology can shorten the time needed to construct an ontology, increasing the likelihood that the project will succeed. METHONTOLOGY is used in the specification, conceptualization, formalization, implementation, and maintenance phases of the ontology building process. Adherence to relevant norms and laws has been widely established during the ontology creation. Only the conceptualization—the process of organizing knowledge for ontology implementation—is the subject of this paper. The conceptualization of the tasks in the task set for knowledge structuring is included in methodology. It makes ontologies buildable at the knowledge level. The developed ontology is meant to serve as a domain knowledge base for further programs, including expert systems.

Keywords: *Rubric Assessment, Ontology, Higher Education, Psychomotor Learning Domain.*

1. INTRODUCTION

Education is a valuable tool that should use on a daily basis. People receive education from early age, beginning at home. Subsequently, pursue education at the preschool, primary, secondary, post-secondary, and, ultimately, tertiary levels [1]. Students can enroll in postsecondary institutions after completing their secondary education. University-based post-secondary education is referred to as tertiary education. A university, often known as a higher education institution is a prestigious educational setting where academic research is conducted and students pursue degrees. Higher education institution are educational institutions offering courses in a range of subjects, including medicine, engineering, teaching, shipping, management, and more. Higher education institution seeks to improve student outcomes through variation. Assessment is one of the method to evaluate the quality of student that used by educator through assignment, final year project, homework, report, field research and etc. Assessments play a critical role in evaluating student performance across various levels and disciplines.

Rubric is one method of evaluating student achievement in all areas of their work [2], including the written, spoken, and visual components. A rubric helps educator hold students accountable for their performance in an intelligible way by defining expectations for them and offering information on how to meet them (learning outcomes). Rubrics are necessary for educators to know what their pupils need to accomplish in order to achieve at a higher level [3]. Apart from denoting certain degrees of achievement, Brookhart [4] notes that it can promote education and align with grading standards. Rubrics are used to provide equitable assessment and consistent grading, communicate expectations to students, provide timely and informative feedback, and encourage learning and self-evaluation on the part of the students. A rubric, as a standardized assessment method, provides clear guidelines to students and educators. It ensure equitable evaluation and promoting learning outcomes. However, it took for those who weren't familiar with rubrics to learn how to use them, as the design of the rubric and the language needed to be understandable to students [5]. The effective design and implementation of rubrics are challenging, particularly for domains requiring psychomotor skill assessment. Current tools and models for rubric-based assessments often lack comprehensive support for psychomotor domains, delaying their usability and adaptability in education. So, creating a rubric needs more time, it is complicated, and need an expert to verify the rubric [6]. Additionally, there is limited standardization across institutions, which obstructs knowledge sharing and collaboration.

Rubric assessment is a concept that explaining the need to standardize between institutions, to solve the problem of the common interest in a given domain. Managing knowledge in rubric assessment especially for psychomotor learning domain is complex, but promoting knowledge sharing based on standards and common term agreeable to all lecturers is essential and it is something that must be development. The primary issues in this study addresses is the lack of a standardized and reusable ontology model in term of psychomotor learning domain. Existing ontology-based assessment models, such as ON-SMILE and xAPI, do not fully address the specific needs of psychomotor rubrics, limiting their applicability in higher education. This gap effects the quality of assessments, making it difficult for educators to design effective rubrics that aligned with learning outcomes. In this case, ontologies, as a conceptual tool and a key component of knowledge-based system, that have been used by organizations for effective knowledge management of the domain of discourse. According to study by Mizoguchi & Bourdeau [7], ontology needs to meet four basic requirements: (i) flexibility; (ii) explicit conceptualization; (iii) standardization for reuse; and (iv) theory-awareness [8].

In the context of the study, knowledge and ontological engineering were suggested as viable approaches to accomplish these goals. Institutions are able to share this ontology model. Along with acquiring specialized knowledge, developing and evaluating general abilities is crucial in higher education [9]. Skills and abilities that are universally applicable in any particular profession are known as generic skills. The purpose of this study is to generalize the rubric so that it may be applied to programming and computer science domains that share the trait we need to assess. This indicates that this ontology model can be used for any subject that uses programming, including object-oriented, web, and fundamental programming.

There are many methodologies that have been proposed to develop ontology model by several research during the last decade. However, designing a domain ontology for rubric assessment needs a well-define ontology development methodology. The ontology model of Psychomotor Learning Domain (PLD) will make an assessment based on the characteristics of the level psychomotor and provide task based level of psychomotor that appropriate to the assessment and rubric that want to create and used for student. PLD will help educators to create a task and rubric based psychomotor level. This paper focuses on development of PLD model using METHONTOLOGY.

This paper aims to develop the PLD ontology model using the METHONTOLOGY framework to provide a structured, reusable, and standardized approach for creating rubric-based assessment in the psychomotor domain. By addressing the identified gap, the study seeks to improve the quality and consistency of assessments in higher education. In this paper, the process of designing and developing the PLD model in the conceptualization phase will be explained. Section 2 is intended to present the related works based on the METHONTOLOGY approach. Section 3 is for research design. Section 4 is the process of building the PLD Ontology and section 5 for discussion. The conclusion is briefly discussed in section 6 which represents the result.

2. RELATED WORK

Ontology is a formal, clear specification of a common understanding [10]. It indicates that machines are able to read ontologies. It represents clearly defined concepts and constraints. An ontology ought to model the ideas and relationships within the domain and reflect a common understanding of it. The use of ontology technology in research and model creation has numerous benefits across numerous fields. Table 1 shows the ontology that used for assessment that mostly applied in education.

Table 1: Ontology-based Assessment.

Ref.	Assessment	Framework/ Model/ Tool	Ontology
[11]	Social life cycle assessment	Ontology-based social life cycle assessment–aided design method	LCA (Life cycle assessment) ontology
[12]	MCQ (Multiple Choice Question) technique	Automatic Question Generation (AQG) using question templates	Mapping ontology – domain ontology with MCQ ontology
[13]	Formative and summative assessment Analytic, holistic and primary trait	ON-SMMILE tool	Student Model ontology, IMS Learning Design ontology, Assessment Rubric ontology and Performance Indicator ontology
[14]	Assessemnt analytics - Formative assessment (MCQ)	xAPI tool	AAOntology (Assessment Analytic)
[15]	Comprehensive Integrative Puzzle (CIP) assessment questions	Comprehensive Integrative Puzzle (CIP) assessment method and architecture	OntoCIP ontology (Task ontologies category)
[16]	SQL assessment	NA	SQL ontology
[8]	Flexible instructional results in adult literacy	IDont - an ontology based framework for modeling instructional design	Context ontology, Goals ontology, Process ontology, Content ontology, Evaluation ontology, Domain ontology
[17]	Formative assessment (automatic generation of MCQ tests from arbitrary domain ontologies)	Onto2MCQ tool	Biochemistry ontology, Economics ontology, Law ontology, Music ontology
[18]	Ontology-Based Model for Authentication and Auto-Grading Online Submission of Psychomotor Assessments	NreASAM	NreASAM ontology
[19]	Rubric based assessment	IMS Caliper	NA

Numerous techniques are employed in the computational approach. The researchers employed an appropriate strategy to address the problems that arose [20-22]. Yago et al., [13] developed an ontology model to understand students and their level of knowledge and provides assessments based on rubrics, various learning objectives, and units of study. Hussain et al., [23] produced WEKA tools to evaluate academic students' performance and decrease dropout rates. According to research done by Probst et al., [24], educators employ rubrics in the form of a mobile application. To participate in the student evaluation, they only need to bring their phone. Whereas in another research done by Azmi et al., arabic student essays were automatically assessed using AAEE. In order to confirm the validity of the tools, AAEE was utilized to automatically analyze student essays in the Arabic language using one hundred essays [21]. Czajka et al., [25] developed "feedback-style" rubrics using a web-based system that include observable traits and recommendations for students to get better result performance in the area of STEM. Nevertheless, the technologies found on the website are already implemented and practically used according to research by Nouira et al., [14] and the website 1EdTechTM Consortium [19].

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There are only three tools applied the ontology concept models that were utilized to construct the rubric-based assessment which are ON-SMILLE, xAPI, and IMS Caliper, as indicated in Table 2. The Student Model ontology, the Assessment Rubric ontology, the Performance Indicator ontology, and the IMS Learning Design ontology are the four ontologies that had been used in ON-SMILLE. xAPI- compliant learning environments employ tools that capture student interactions and share that data with other environments via users and ontologies that meet xAPI specifications. However, xAPI does not pay much attention to precise evaluations. The IMS Caliper tools do not disclose the exact ontology ideas that are involved in the design of the rubric; instead, the UML diagram of the rubric and all of the concepts that are related to it may be found on the 1EdTechTM Consortium website. 1EdTechTM Consortium claims that the rubric was developed using ontology. Table 2 displays the computational approach in education that is based on rubrics.

Table 2: Rubric-based Computational Approach in Education.

Ref.	Tools	Computational Approach
[13]	ON-SMMILE	Ontology
[23]	WEKA	Data mining tools and technique
[22]	e-rubric	Mobile application
[21]	AAEE	Web based
[14]	xAPI	Ontology
[20], [25]	ELIPSS project	Web based
[19]	IMS Caliper	Ontology

Reusing ontology is possible, particularly in the same domain as pre-existing ontologies in order to save cost (human resources) and time. Based on its intended use, researchers have constructed the ontology model in a variety of ways. It can be demonstrated that Panulla & Kohler [26] created the rubric-based ontology included in Assessment Rubric ontology, which was then reused in the ON-SMILLE model. This model demonstrates how to reuse the ontology model, which can speed up the process of learning about ontology. The Cyc technique, Uschold and King, Gruninger and Fox, Cactus, METHONTOLOGY, Sensus-based, On-to-Knowledge, and many other approaches are used in the development of ontology. METHONTOLOGY was used to standardize the IEEE and make it appropriate for developing the engineering ontology [27]. The researcher concludes that METHONTOLOGY is the most developed technique and offers rules for re-engineering ontologies, although there are still some suggestions for pre-development procedures. The METHONTOLOGY framework makes it possible to generate ontologies at the knowledge level using a life cycle based on developing prototypes, procedures for ontology development, and processes for every task [28][29]. Table 3 shows the project that used methodology METHONTOLOGY to build an ontology model.

Table 3: Project that used METHONTOLOGY.

Ref.	Aim	Field	Ontology model
[30]	Help to choose smartphone with existing criteria, brands, prices to features that potential buyers must consider in buying a smartphone	Device (Smartphone)	Smartphone ontology
[31]	To visualize the doctoral research output in Library Information Science	Library and Information Science (LIS)	Theses ontology
[32]	Retrieval relevant concepts and verses of scientific miracles in the Holy Quran	Semantic web?	Scientific Miracle Ontology (SMO)
[33]	Improve agricultural practices to make optimal decisions of knowledge about rice varieties in terms of variety selection, yield	Agriculture	Ontology Varieties Rice (OntVarRice)

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Ref.	Aim	Field	Ontology model
	potential, production quality, pest, and disease resistance		
[34]	In the assembly task of the ignition target, engineers can quickly and accurately access the required assembly knowledge from the ignition target assembly knowledge model	Product development (manufacture)	Microdevice assembly ontology
[35]	Supports the explicitness of the theme and enables the creation of systems that act to solve the turnover challenge	People management	OntoTurnover

This methodology's domain independence makes it useful for many ontology creation projects [29][30]. The degree of adoptability by non-experts, the process and level details of the procedure, support for iterative development tasks [36], formalization recommendations, tool support, suggested methods, and the step-by-step ontology building process are some of the metrics that were used to determine the appropriate methodology for building the model [32][33][34]. METHONTOLOGY is the best suitable methodology to construct an ontology model, taking into account all the factors.

3. RESEARCH DESIGN

The research design follows the METHONTOLOGY framework, a well-structured methodology for ontology development, to address the research problem. METHONTOLOGY is chosen for its systematic approach, enabling the construction of a reusable and domain-independent ontology. The research design involves the following phases that state in Figure 1.

Five phases in the development activities in METHONTOLOGY such as specification, conceptualization, formalization, implementation, and maintenance. Discussion focuses on conceptualization which will be used to organize the knowledge based on experts in this domain. The objective of conceptualization is to employ external representation to organize the information learned during the knowledge acquisition activity. A conceptual model is constructed and converted into a codified model that a machine can comprehend from the conceptual level to the implementation level. To achieve the consistency and completeness of the knowledge represented utilizing the METHONTOLOGY approach, there are a few procedures that need to be taken.

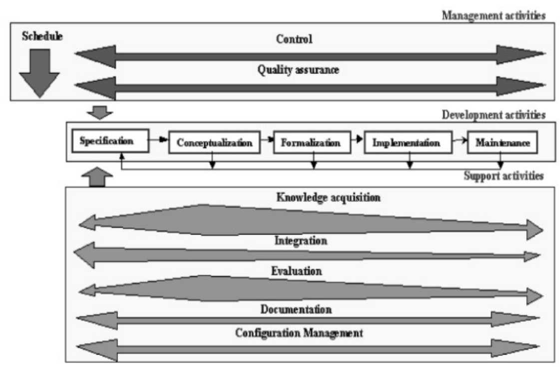

Figure 1: Phase in METHONTOLOGY.

The specification phase identifies the purpose and scope of the ontology, focusing on rubric-based assessments within the psychomotor learning domain. Requirements are defined through literature reviews and domain expert interviews to capture relevant attributes and challenges. Conceptualization organizes knowledge into structured formats resulting from expert input and research literature. Key terms, taxonomies, and relationships specific to psychomotor assessments are developed, such as terms like "guided," "proficiency," and "motor movement," to establish a clear vocabulary. Formalization translates the conceptual model into a machine-readable format using the Web Ontology Language (OWL), where formal axioms and logical rules are established to ensure consistency and usability of the ontology model. Implementation utilizes tools such as

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TopBraid Composer to construct and test the ontology. SPARQL queries validate its structure and functionality, confirming accurate relationships and logical consistency. Finally, evaluation tests the ontology's accuracy and practical effectiveness in real-world scenarios, refining the model based on feedback from Subject Matter Experts (SMEs).

Tools such as TopBraid Composer facilitate ontology building and testing, while SPARQL queries ensure logical consistency and proper implementation of relationships. The PLD ontology model is expected to provide a standardized framework for psychomotor rubric assessments, enhance knowledge sharing and collaboration among educators, and serve as a reusable model applicable to related educational domains, such as cognitive and affective learning domains.

Designing and creating the ontology-based supporting infrastructure and tools that will be tested in a higher education setting is the final step in achieving the third goal. Following that, an automatic consistency check will be used to analyze the ontology model. Additionally, this ontology model will assess its use in the tool that is developed by gathering expert input through questionnaires and interviews. The primary goal of developing the ontology model is to instruct and direct educators in developing rubrics for assessments at the domain-based level of psychomotor learning. As a result, the ontology is essential for organizing domain experts' knowledge into a machine-readable format. An ontology model can be used to represent any specific relationship between various classes.

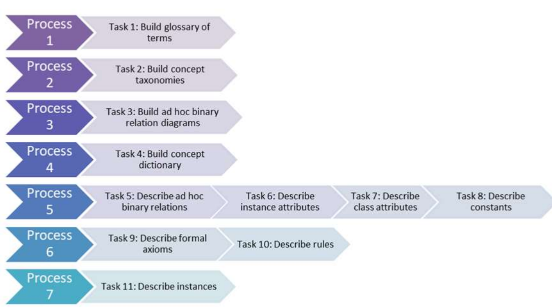

Figure 2: Process and task of the conceptualization activity according to METHONTOLOGY.

This process represents how the ontology classifying level of psychomotor learning domain is developed using conceptual phase in METHONTOLOGY. Figure 2 shows the ontology building tasks suggested in METHONTOLOGY framework. Section 4 is a thorough explanation of the ontology construction approach.

4. DEVELOPMENT OF ONTOLOGY

There are three objective to be achieved in this research that is to study and analyse the relation between higher education challenges and ontology, to design and develop ontology model based assessment, and to evaluate the PLD ontology model by test it using TopBraid. Every objective has a step-by-step procedure that must be followed in order to produce an output. The process of first step is to identify the current issues that have occurred in higher education institution from journals, articles, websites, and reports. These current issues will focus on assessment especially in rubric especially to build the rubric assessment by educator. Existing ontologies were also analyzed to find out the relationship between the current issues and the existing ontologies. Systematic literature review process is implemented in this phase.

Next step is to design an ontology model by getting information based on attributes and properties obtained from journal reviews and from a series of domain expert interviews. Comprehensive reviews in researches are also important to identify the purposes and for concrete justification of designing the ontology model. The ontology model's static knowledge and dynamic knowledge can be formulated by defining the concepts, semantic relationships, attributes, constructing formal axioms, and logic rules. In this phase, the methodology for constructing a model is identified as METHONTOLOGY. This methodology is proposed because many other ontology tools and tool suites can be used [36][39]. If there is a problem occurring after an activity, the process can return to any of the previous activities to solve the problem. There are many ontology editors that can be used to develop a model such as Protégé, SWOOP, NeOn Toolkit, TopBraid Composer, and others. The ontology model in this research built using the TopBraid Composer tools. The concepts, semantic relationships, attributes, formal axioms, rules, and individuals are coded into the Web Ontology Language (OWL) format.

A detailed description of the methodology of ontology building can be found in [33]. The step followed are based on the type of ontology that is the lightweight ontology. As for the PLD ontology, the steps are stated below.

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4.1 Build Glossary of Terms

A set of terms is included in the ontology of glossary. It includes natural language definition, synonyms, and acronyms (option). Several feature data dictionaries obtain from WordNet and Kamus Dewan, in order to build a complete ontological frame. This glossary contains 30 concept related to psychomotor learning domain. Table 4 shows a part example of glossaries.

Table 4: Glossary of Terms of Psychomotor Learning Domain (PLD) Ontology..

Name	Synonyms	Description	Type
Thing	-	Superclass of all other classes	Concept
behavior	characteristic	Characteristic of psychomotor	Concept
learning Domain	-	Learning Domain in education	Concept
skill	task	Specific task to be evaluate	Concept
verb	-	Verb that used in psychomotor level	Concept
guided	-	Material that used to follow	Concept
keyword	Material	Verb that used as keyword in certain level of psychomotor	Concept
motorMovement	Motor sensory	Motor sensory movement that used in certain level of psychomotor	Concept
proficiency	-	Proficiency that used in certain level of psychomotor	Concept
readiness	Preparation	Prepare for used or action	Concept
sensory	-	Sensory of a nerve fiber or impulse originating outside and passing toward the central nervous system	Concept
psychomotor	-	Learning domain	Concept
adaptable	Suitable	Capable of adapting in term of proficiency	Concept
advance	-	Better progress in term of proficiency	Concept
creative	Originative	Having the ability or power to create	Concept
intermediate	-	Competently respond to stimulus for action	Concept
hasGuided	-	Material that used to do assessment	Relation
hasKeyword	-	Verb that used specific keyword	Relation
hasReadiness	-	Prepare in term of mental, physical or emotional	Relation
hasSensory	-	Used sensory such as Touch, smell, hearing, sound, taste, interoception, proprioception, vestibular, sight	Relation

4.2 Build Glossary Taxonomies

The aim of this step is to define the concept of hierarchy (using top-down, bottom-up, and middle-out). Taxonomy was developed which was used to determine the validity of the methodology. A solid taxonomy is necessary to order and organize the related concepts in the contractual relationship. METHONTOLOGY uses *Subclass-Of*, *Disjoint-Decomposition*, *Exhaustive-Decomposition*, and *Partition*. There are only 3 taxonomies relation in the PLD ontology.

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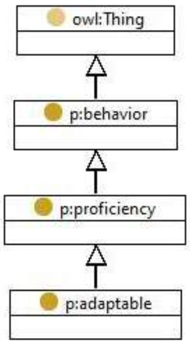

Figure 3: Subclass-Of relation.

Figure 3 shows the Subclass-Of relations. `behavior` is a subclass of `Thing`, since every PLD characteristic (`proficiency`, `adaptable`) is an `owl:Thing`.

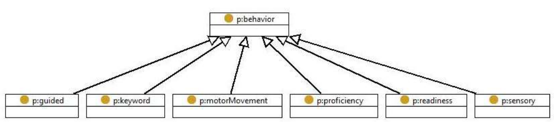

Figure 4: Disjoint-Decomposition.

A *Disjoint-Decomposition* is a set of subclasses of behavior that do not have common instances and do not cover behavior, that is, there can be instances of the concept of behavior that are not instances of any of the concept in the decomposition. Figure 4 shows concept of behavior has a subclass that is `guided`, `keyword`, `motorMovement`, `proficiency`, `readiness` and `sensory` that do not share instance with each other. That will make the taxonomic relations as *Disjoint-Decomposition*. Each of the behavior has a different psychomotor learning domain level.

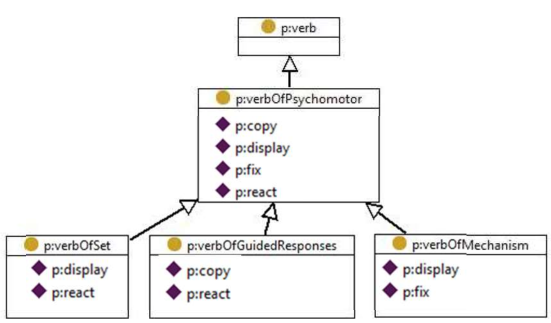

Figure 5: Exhaustive-Decomposition.

An *Exhaustive-Decomposition* is a set of subclass psychomotor that cover psychomotor and may have common instances and subclasses, that is, there cannot be instances of the concept psychomotor that are not instances of at least one of the concepts in the decomposition. Figure 5 shows of a part of the ontology model that has this type of relationship where concept `verbOfSet` has same instance that is react with concept `verbOfGuidedResponses`. Concept `verbOfSet` also has same instance with concept `verbOfMechanism` that is display.

4.3 Build ad hoc Binary Relation Diagrams

Ad hoc binary relation diagrams will establish the ad hoc relationship between concepts of the same (or different) taxonomy. The domain and ranges of each argument of each relation defined exactly and precisely the classes that are suitable for the relation.

4.4 Describe ad hoc Binary Relations

Next step is to describe all the ad hoc binary relations included in the concept dictionary, and to produce the ad hoc binary relation table. Table 5 shows a part of an excerpt of the ad hoc Binary Relation table of the PLD ontology.

Table 5: A Part of an Excerpt of the ad hoc Binary Relation of the Psychomotor Learning Domain Ontology.

Relation name	Source concept	Source card (max)	Target concept	Inverse Relation
hasConjunction	conjunction	1	guidedResponses	is conjuction of
hasGuided	guided	1	guidedResponses	is guided by
hasSensory	sensory	1	perception	Use sensory
hasProficiency	proficiency	1	mechanism, complexOverResponse, adaptation, origination	is proficiency of
hasReadiness	readiness	1	set	is readiness of
hasMotorMovement	motorMovement	1	complexOverResponse	is motor movement of

.

4.5 Describe Formal Axioms

Formal axioms developed and used to detect and certify ontology consistency, find dissatisfied classes, improve interoperability, guide

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ontology extension through the application of axiom-based design patterns and encode domain background knowledge.

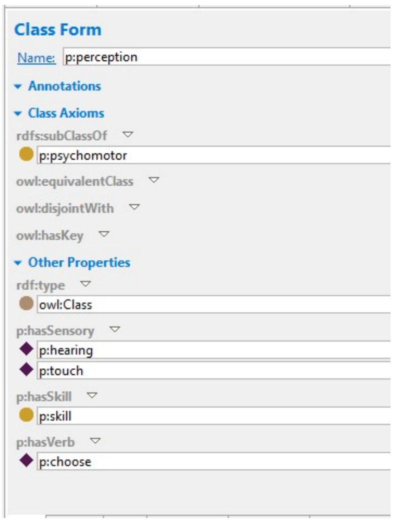

Figure 6: Class Form (Class Axioms) for `perception`.

As seen in Figure 6, class axioms are discovered and the logical statement is manually added. The axioms supplied into the class form interferes by TopBraid. It show the class form for `perception`.

5. DISCUSSION

Ontology construction from scratch is difficult. Its construction is complex, time-consuming, and demanding due to the unstructured knowledge from various sources and the need for domain experts and ontology developers to come to a consensus. Therefore, it is imperative to build appropriate procedures that will act as recommendations for the development of ontologies. Several approaches, including the Cyc technique, Uschold and King's method, Gruninger and Fox's method, Kactus approach, METHONTOLOGY, Sensus-based method, and On-to knowledge, can be used to construct ontologies. The designs and execution processes of each of these approaches are unique. As a result, the applications and intended goals determine which ones are chosen. However, METHONTOLOGY was employed since it is one of the approaches that provide a comprehensive flow and set of procedures for creating an ontology model.

Manually creating an ontology model is quite difficult and time-consuming because it heavily relies on the knowledge of subject experts. Even though the METHONTOLOGY technique serves as the basis for the construction of PLD ontology, it is still advisable to conduct numerous interviews with subject matter experts in order to get sufficient knowledge for constructing the ontology model independently. Thus, without the assistance of domain specialists, ontology learning and mapping research can be used to automatically discover and construct concepts, relationships, and individuals in ontology models. The PLD model made use of the psychomotor domain learning concept—which involves learning from an expert—and the original model ontology from Panulla & Kohler [26].

PLD model will be tested using SPARQL query, where it can be tested using software TopBraid. The interface of SPARQL in the query editor, as in Figure 7. The query being tested, either the result that gets is correct when it applies all the conditions in the query. A part of the test as shown in figure 7 means that the learning domain must be a subclass of `psychomotor`, must have a verb that is a `verbOfPerception`, and must have sensory that is touch. Therefore while the query is running, the result will appear on the right side of the query editor, which is `perception`. So, `perception` meets all the state requirements.

Figure 7: Interface of SPARQL in query editor.

After completing the build of the PLD ontology, the model will be embedded in the system. The system will be developed using the Java programming language. Jena API was used to read the PLD ontology. The educator can use the system independently and the system will guide to create tasks and rubrics for assessments.

PLD ontology model generally focuses on programming subjects and psychomotor learning domains that can also be applied to multiple subjects that are related to programming, such as web programming, basic programming, object-oriented programming, data structure, and others that are related. The process, concept, relation, and attributes can be applied to other relevant fields and other learning domains, such as affective and cognitive. The developed PLD ontology has important practical implications in the current industry and

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educational scenarios. The following aspects highlight its relevance and potential.

The PLD ontology offers a structured and standardized framework for designing rubric-based assessments in psychomotor domains. This standardization can address inconsistencies across educational institutions, ensuring fair and accurate evaluations. Furthermore, with the rise of AI-driven educational tools, the ontology can be integrated into automated assessment systems, enabling scalability and efficiency in evaluating psychomotor skills in virtual or hybrid learning environments.

The PLD ontology reduces the time and effort required for educators to create rubrics by providing reusable models and allowing them to focus on improving instructional strategies. While primarily aimed at psychomotor assessments, its adaptability extends to cognitive and affective learning domains, thus expanding its interdisciplinary utility. From an industrial perspective, the ontology bridges the gap between academic assessments and the evolving skill requirements of various sectors. As industries increasingly value psychomotor and practical skills, the PLD ontology ensures students are better prepared for workers' demands.

The results of this study prove the successful development of a PLD ontology using the METHONTOLOGY framework. The ontology addresses the identified gap by providing a standardized and reusable model for rubric-based assessments in psychomotor domains. The evaluation results indicate that the ontology is effective in supporting educators to design and implement rubrics more efficiently while maintaining consistency and accuracy. However, the development process also revealed certain limitations, such as the dependency on expert input during the conceptualization phase and the need for further testing in diverse educational settings. Future research can explore integrating the PLD ontology into AI-driven assessment platforms to automate rubric creation and expand its applicability.

6. CONCLUSION

This research successfully developed a PLD ontology that addresses the challenges of standardizing and improving rubric-based assessments in psychomotor learning domains. By adapting the METHONTOLOGY framework, the study provided a structured approach to ontology development, ensuring the model's reusability and scalability. The PLD ontology has significant implications for education and industry, fostering better alignment between academic assessments and workforce needs. Future work will focus on refining the ontology's application in real-world scenarios and extending its capabilities to other learning domains such as cognitive and affective.

METHONTOLOGY describes the detailed process to build the ontology step by step. As a result, the psychomotor learning domain ontology model has been designed as shown in Figure 8. It is used to classify task based on psychomotor level. A customized structure as well as classes, subclasses, and properties are defined. It includes `owl:Thing`, `behaviour`, `learningDomain`, `skill`, `verb`, `psychomotor`, `guided`, `keyword`, `motorMovement`, `proficiency`, `readiness`, `sensory`, `adaptable`, `advance`, `creative` and `intermediate`.

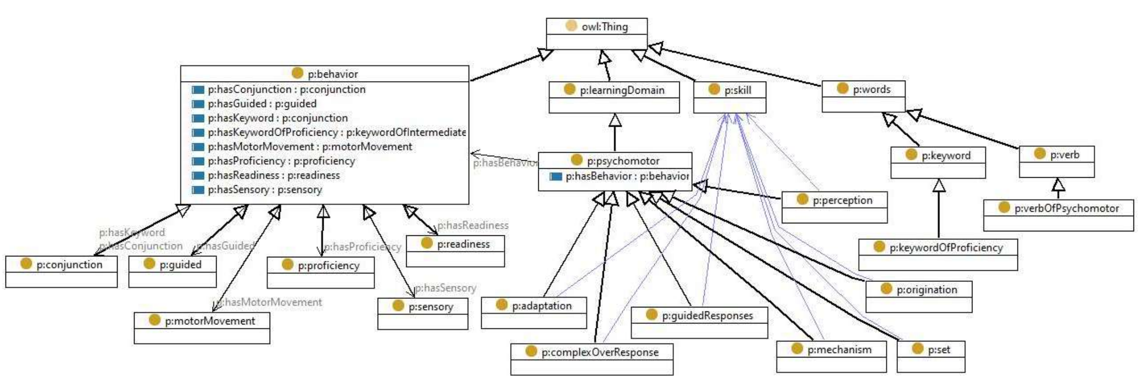

Figure 8: Ontology Model of PLD.

The ontology model of PLD will then, be integrated into a web-based system. The accuracy of the system's output and the results of the SPARQL query will be used to evaluate the model. The Subject Matter Experts (SMEs) will do the evaluation ontology model to gather insights and improve the model based on user needs. The model will provide an appropriate rubric to assist educators in improving the quality of their instruction and evaluation in the classroom.

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