

Exploring Terminological Consistency of Project Management Glossaries

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***Abstract.** The present paper deals with an exploratory study on the terminological consistency of four selected project management glossaries. To systematically carry out the study, eight activities were established. Regarding the information consistency sub-characteristic, this work includes a comparison and analysis of both the syntactic and semantic consistency of the terms in the glossaries. To do this, nine terminological categories were conceived for the project area, in which, for each glossary, a given term is included in a category, considering the semantics intended in the definition of the term by the authors. This categorization of terms allows us to comparatively analyze syntactic and semantic similarities, and in turn consistencies and inconsistencies. As a final goal, this study will help us examine our previously developed project ontology and recommend adoptions and adaptations.*

1. Introduction

To support the understanding and learning of frequently used concepts for the project management discipline, there are several initiatives that have developed project management glossaries. A glossary, regardless of whether it is for project management or not, includes entries, that is, terms that designate concepts and their definitions –and occasionally synonyms, acronyms, references, and additional notes- often taking into account recognized sources in a given area.

Therefore, glossaries serve as an authoritative reference to establish a common conceptual foundation for terms and definitions, not only in understanding and learning but also in communicating with different stakeholders.

Thus, an entire profession and discipline have been focused on improving software engineering approaches, processes, methods, and tools, so any professional in the field of software engineering will have come across and used many glossaries, whether in their formal training or their daily work. In particular, most professionals in the field of project management are familiar to some degree with glossaries such as PMBOK which stands for Project Management Body of Knowledge (PMBOK, 2021), APM which stands for Association for Project Management (APM, 2021), IAPM which stands for International Association of Project Managers (IAPM, 2021), and PRINCE2 which stands for PRojects IN Controlled Environments (PRINCE2, 2017), to mention just a few existing project management glossaries, but which were the ones selected for the present study.

Terminologies can be conceived and developed from lesser to greater structural

richness, such as glossaries, taxonomies, and ontologies. In Rivera et al. (2016), the authors built the first version of a project ontology, which adapted some terms from PMBOK. Later, in 2019, a five-tiered ontological architecture was developed by Olsina (2021) where the cited project ontology was located at the core level. However, a current review of its core concepts and relationships will be beneficial by considering terms from a selected set of up-to-date project management glossaries.

For this, we carry out an exploratory study in order to analyze the most frequent terms in the abovementioned glossaries, which in turn present the highest levels of syntactic and semantic consistency. The main goal of this study is to help us examine the previously developed project ontology concepts and recommend adoptions and adaptations of some terms from project management glossaries. It is important to remark that the comparative analysis to recommend the adoption or adaptation of terms in the new version of the project ontology will be limited to generic terms that can be placed at the core level rather than at the domain level.

Additionally, this comparative analysis will allow us to gauge the level of syntactic and semantic harmonization existing in these terminologies. Since glossaries serve as a common conceptual basis for different stakeholders, a given discipline or field –like project management- will become more mature if terminological consistency and harmonization are promoted and achieved.

To systematically conduct this research, eight activities or steps were established. To compare and analyze the information consistency sub-characteristic, this work includes both the syntactic and semantic consistency of the terms in the glossaries. To perform this, nine terminological categories were conceived for the project area, in which, for each glossary, a given term is included in a category, considering the semantics intended in the definition of the term by the glossary authors. This categorization of terms allows us to comparatively analyze syntactic and semantic similarities, and in turn consistencies and inconsistencies.

The remaining sections of this paper are organized as follows. Section 2 establishes the eight activities carried out for this exploratory study on terminological consistency, in addition to developing and illustrating each activity in detail, dedicating a subsection to each one. Section 3 highlights related work. Finally, Section 4 outlines our conclusions and future work.

2. Process and Development of the Exploratory Study on Syntactic and Semantic Consistency in Terms of Project Management Glossaries

To carry out this exploratory study on the comparative analysis of the consistency of both syntactic and semantic information for project management glossaries, we have established the following activities or steps:

- **A1.** Define the evaluation goal and scope of the comparative analysis.
- **A2.** Select project management glossaries to be compared.
- **A3.** Design terminological categories for the project management area to evaluate syntactic and semantic consistency.
- **A4.** Put glossary terms into categories taking into account the semantics intended by glossary authors in their definitions and count them.

- **A5.** Calculate the frequency of terminological occurrence (syntactic similarity) considering the primary terms or their synonyms.
- **A6.** Calculate the categorical coincidence (semantic similarity) considering the syntactic similarity of the terms.
- **A7.** Analyze syntactic and semantic consistency.
- **A8.** Recommend adoptions and adaptations.

It is worth noting that while this process instance deals with our current study applied to project management glossaries, this activity sequence can be used and adapted for any syntactic and semantic comparative analysis of terms in glossaries of other domains. Thus, in previous studies applied to software testing glossaries by Tebes et al. (2022) and Olsina et al. (2022), although the above process was not explicitly listed, we can affirm that the only slightly adapted activity was A8, in which improvement actions were recommended instead of adoptions and adaptations as in the present work.

The following eight subsections discuss and illustrate the procedures and results of the activities listed above.

2.1. Defining the Goal and Scope of the Exploratory Study

Activity A1 aims to define the objective of the evaluation, the motivation, and the scope of this study within the area of project management terminologies.

The statement of the evaluation goal of this exploratory study can be briefly formulated as “Compare and analyze the syntactic and semantic consistency of terms in the latest versions of project management glossaries used for training and certification worldwide”. Hence, the purpose of the evaluation goal is to ‘compare’; the purpose of the information need goal is to ‘analyze’ –by performing a comparative analysis of categorized terms with the ultimate end of adopting/adapting them in a previously developed ontology; the main particular entity is ‘project management glossary’; the evaluation focus is ‘consistency’ –by considering the suitability of both syntactic and semantic information; and the context is ‘the latest versions of official or de facto international glossaries used for training and certification worldwide’.

The motivation of this study lies in the further updating of a previously developed project ontology (Rivera et al., 2016), which should be located at the core level in the context of a five-tiered ontological architecture. For this, we conduct this study in order to analyze mainly the most frequent terms in the selected glossaries, which in turn evidence the highest levels of syntactic and semantic consistency. The scope for the comparative analysis to recommend the adoption or adaptation of terms in the new version of the project ontology will be limited to generic terms that can be placed at the core level rather than terms that are more domain-specific such as "Agile project management", "Agile method", "Sprint", or "Scrum", among others.

Note that Table 1 defines a reduced set of sub-characteristics and attributes of Information Quality, which was also used in a previous study by Olsina et al. (2022). In particular, it defines the Consistency sub-characteristic and its two attributes that will be used in subsections 2.5 through 2.7 to design metrics, get values, and analyze results.

Table 1. Extract of sub-characteristics and attributes of Information Quality

Characteristic/Attribute	Definition
Information Quality	The degree to which a product or system delivers accurate and suitable information which meets stated and implied needs when used under specified conditions.
1 Information Accuracy	The degree to which a product or system delivers information that is correct, credible, and current.
2 Information Suitability	The degree to which a product or system delivers the information with the right coverage, added value, and consistency , considering the specified user tasks and intended goals.
2.1 Consistency	The degree to which the information is coherent both semantically and syntactically against informational things, parts, categories, or human expressions previously shown or stated and agreed upon.
<i>2.1.1 Syntactic consistency</i>	<i>The degree to which the information has the necessary and sufficient keywords to coherently convey the message in a given natural language in front of something previously stated and agreed upon.</i>
<i>2.1.2 Semantic consistency</i>	<i>The degree to which the information coherently conveys and harmonizes meaning with something previously stated and agreed upon.</i>

2.2. Selecting Project Management Glossaries

As pointed out in the Introduction Section, the four project management glossaries analyzed are PMBOK, APM, IAPM, and PRINCE2. Table 2 shows in the first row the edition/year of each glossary. These four project management glossaries were chosen among eight shortlisted candidates applying the following selection criteria, namely: i) It must be written in English; ii) Must be used for training and certification purposes; iii) Must be updated between January 2017 and January 2022; and, iv) The latest version/edition can be accessed publicly or through our academic institution. The reader can find summary information and criteria met by the eight glossaries in Appendix I at https://bit.ly/CibSE_Appendices. Note that the excluded glossaries are mainly due to criterion iii). A brief description and figures of the four included glossaries follow.

The PMBOK is a go-to document for effective project management in any industry. This resource results from work overseen by the Project Management Institute, which also offers certifications. It includes the standard for Project Management, which is the foundation upon which the vast body of knowledge builds, and the guide serves to capture and summarize that knowledge. The glossary generally does not include domain-specific terms. The current version is the 7th edition, which was released in July 2021 and includes a glossary with 350 primary terms and 3 synonyms (see Table 2).

The APM glossary was created by the Association for Project Management and was last updated in 2021. It is a collection of popular project management terms sourced from the 5th, 6th, and 7th editions of the APM Body of Knowledge and other APM publications. APM says its glossary is the common reference for project professionals in their daily work, for students studying APM qualifications, and for training providers looking to create study materials. Table 2 shows the term numbers that are overwhelmingly larger than the other three.

The IAPM Glossary is currently an online English-language resource for agile and project management terms created by the International Association of Project Managers. This organization is a global certification authority for project managers. The glossary has 333 primary terms and 41 synonyms.

Table 2. Number of terms for the four project management glossaries

Metric name	PMBOK	APM	IAPM	PRINCE2
Glossary edition/year	7 th Ed./2021	2021	2021	6 th Ed./2017
Total Number of Primary Terms per Glossary	350	753	333	197
Number of Synonyms per Glossary	3	51	41	3

PRINCE2 is a glossary, which is also a process-based method for effective project management, as well as a project manager certification program. The PRINCE2 certification is recognized worldwide. It has 197 primary terms and 3 synonyms.

2.3. Designing Terminological Categories for Project Management Glossaries

Concerning activity A3, nine terminological categories were designed, in which, for each glossary, a certain term is included only in one category in activity A4, considering the semantics intended by the authors of a given glossary. Designing categories followed by placing glossary terms in them will allow us to calculate syntactic and semantic similarities and then analyze consistency and give recommendations for adoption.

Table 3 exhibits the nine terminological categories we have conceived for project management glossaries. The terms that we are going to include in categories 1 (C1) to 8 (C8) are those terms that are primarily related to the area of project management. Instead, C9 is intended to incorporate terms belonging chiefly to other areas, although they may also be used in projects, such as the term "Contract".

The rationale for the design of these categories takes into account those developed in the exploratory studies for the software testing glossaries mentioned above. A similar approach is considered in the present research. For example, we share the same conceptual patterns for C2, C3, C5, C6, and C7 categories. However, the former C3 (Test Goal-, Requirements-, Entity-related Terms) is now divided into two categories, i.e., in C1 and C8, as shown in Table 3. What is new, is the category C4. It is worth mentioning that the project management area has a greater number of generic terms than the software testing domain, as we will discuss later.

Table 3. Names of the nine terminological categories for terms in project management glossaries

Category ID	Terminological Category name
C1	Goal-, Objective-, Purpose-, Intention-related Terms
C2	Strategy-, Approach-, Framework-, Principle-, Policies-related Terms
C3	Work Process-, Activity-, Step-related Terms
C4	Situation-, Event-, Condition-, Action-related Terms
C5	Method-, Technique-, Procedure-, Decision Criterion-, Rule-related Terms
C6	Work Product-, Artifact-, Result-, Representation-related Terms
C7	Agent-, Role-, Tool-, Responsibility-, Skill-, Capability-related Terms
C8	Organizational Entity-, Asset-related Terms
C9	Miscellaneous Terms

Category 1 is called "Goal-, Objective-, Purpose-, Intention-related Terms", which is devoted to covering terms with the semantics of goal, objective, and purpose. Olsina et al. (2021) define the term "Goal" as "*an intention-related assertion, that is, the statement of the aim to be achieved by the organization which considers the propositional content of a goal's purpose in a given situation and time frame*".

Category 2 is labeled "Strategy-, Approach-, Framework-, Principle-, Policies-

related Terms”. In the project ontology built by Rivera et al. (2016), the term "Strategy" is defined as *“Principles, patterns, and particular domain concepts and framework that can be specified by a set of tailored processes, in addition to a set of appropriated methods and tools, as core resources, for helping to achieve the project's goal purpose.”* According to this definition, a strategy or approach simultaneously encompasses at least the concepts of process or activity -what to do- and method or technique -how to do it- when established and used in a given project. As a consequence, the concept of strategy or approach has a broader meaning than the concept of work process or technique alone. In addition, it should be noted that the terms principles and framework appear explicitly in the definition above. Moreover, a strategy may include knowledge and skills as well.

Category 3 is named “Work Process-, Activity-, Step-related Terms”, which is intended to include terms with the semantics of work process or activity. The concepts of the work process, activity, or task in projects generally encompass only the meaning of ‘what to do’ rather than ‘how to do’ an activity or step. So, the terms with the semantics of method or technique pertain to C5. Also, note that these terms are defined in a process ontology at the core level in an updated work by Becker et al. (2022).

Category 4 is called “Situation-, Event-, Condition-, Action-related Terms”. Olsina et al. (2021) define the term "Situation" as *“an assertion that explicitly states and specifies the combination of circumstances, episodes and relationships/events embracing particular entities and their surroundings [...], which is of interest and relevant to be represented by a human agent/organization with an established goal.”* Furthermore, a particular event is seen as an action-related assertion that explicitly states and specifies the occurrence of an entity action.

Category 5 (labeled “Method-, Technique-, Procedure-, Decision Criterion-, Rule-related Terms” in Table 3) is dedicated to including method/technique terms, which have the semantics of ‘how to do’ an activity or task specification. The explicit semantic distinction between glossary terms that represent ‘what to do’ (work process) and ‘how to do’ has a clear benefit for understanding and consistency (Henderson-Sellers et al., 2014). Note that to perform a given activity specification more than one method or technique may be available to be selected.

Category 6 is labeled “Work Product-, Artifact-, Result-, Representation-related Terms”, which is devoted to covering terms with the semantics of artifacts (e.g. reports, specifications, and representations such as models or graphs) or results (values, outcomes) that are produced or consumed by project processes, activities, or tasks.

Category 7 (labeled “Agent-, Role-, Tool-, Responsibility-, Skill-, Capability-related Terms”) is expected to encompass terms with the semantics of automated or human agents. The term tool represents an instrument that facilitates the automation and execution of procedures and rules of methods and techniques, whereas the term role embraces skills that a project agent must possess to perform activities or tasks.

Lastly, Category 8 (labeled “Organizational Entity-, Asset-related Terms”) is expected to encompass terms with the semantics of organizational entities such as the term "Project", among others. An asset is an entity with added value for an organization.

After designing the above categories, we classified each glossary term into its suitable category, as shown below.

2.4. Placing Glossary Terms into Terminological Categories and Counting them

The inclusion of terms in categories for the four glossaries was initially carried out independently by the authors of the present work. Subsequently, the three authors met face-to-face many times to check the consistency. As a result, many issues were raised and categorization discrepancies in the placement of terms according to their given semantics in the definitions were agreed upon and resolved. Note that the volume of primary terms is 1,633. Therefore, the work demanded a lot of effort. The entire period, from the search and selection of the glossaries to the categorization and verification of the terms, was from February to October 2022.

To better understand A4, let us illustrate this step using the term "Project", which is found in all four glossaries. Each glossary entry also has its definition as exhibited in Table 4. In order to categorize a glossary term, we only look at its definition. So the question is, to which category does a term pertain, considering its intended semantics and the conceptual category with previously agreed semantics? Remembering the meaning of each of the nine categories (subsection 2.3), and reading the definition of "Project" in each glossary, it accordingly belongs to C8. The reader may observe a close match in the meaning of "Project" in all four glossaries, although definitions are not identical. This is not the case for many other common terms.

In the first version of the project ontology built by Rivera et al. (2016), we adapted the term "Project" mainly from PMBOK. It was defined as *“an entity representing a temporary and goal-oriented endeavor with definite start and finish dates, which considers a managed set of interrelated activities, tasks, and resources aimed at producing and modifying unique work products (i.e., artifacts, services or results) for satisfying a given requester need”*. In subsection 2.8 we will recommend adoptions/adaptations of terms for the new version of this ontology to be updated.

Table 4. Definitions of the "Project" term in each glossary

Term	Term definition	Glossary
Project	A temporary endeavor undertaken to create a unique product, service, or result.	PMBOK
Project	A unique, transient endeavour undertaken to bring about change and to achieve planned objectives.	APM
Project	Undertaking that is characterised by an overall uniqueness of conditions, such as objectives, time, financial, human resource-related and other constraints, difference from other projects and project-specific organisation structures.	IAPM
Project	A temporary organization that is created for the purpose of delivering one or more business products according to an agreed business case.	PRINCE2

Once all the primary terms –with corresponding synonyms, if any- were placed in categories, the produced tables were documented in Appendices. The reader can find the PMBOK glossary terms categorized in Appendix III of the document at https://bit.ly/CibSE_Appendices. The glossary terms of APM, IAPM, and PRINCE2 are classified and documented in Appendixes IV, V, and VI, respectively.

Another result of A4 is the count of terms by category and glossary as shown in Table 5. Appendix VII also documents the sum of terms by category for all four glossaries together, as well as the percentages. The total sum of primary terms is 1,633, which is obtained by adding each value in the first row of Table 5. This calculation procedure was applied accordingly in each row to obtain the sums by category.

Table 5. Numbers of all categorized terms by glossary

Metric name	PMBOK	APM	IAPM	PRINCE2
Total Number of Primary Terms per Glossary	350	753	333	197
Number of Primary Terms per Glossary in C1	1	4	9	1
Number of Primary Terms per Glossary in C2	27	52	15	10
Number of Primary Terms per Glossary in C3	26	125	43	12
Number of Primary Terms per Glossary in C4	30	86	38	41
Number of Primary Terms per Glossary in C5	40	28	16	6
Number of Primary Terms per Glossary in C6	147	206	95	73
Number of Primary Terms per Glossary in C7	15	51	38	22
Number of Primary Terms per Glossary in C8	7	26	13	10
Number of Primary Terms per Glossary in C9	57	175	66	22

Thus, calculating percentages and excluding C9 (with 19.60%), the highest is observed for C6 (work product) with 31.90%, then for C3 (work process) with 12.61% followed by C4 (situation/event/action) with 11.94%. Besides, C2 (strategy/framework) represents 6.37%, while C5 (method/technique) is 5.51% of all main terms. The lowest percentage is for C1 (goal/intention) with 0.92% which is what could be expected.

2.5. Calculating Syntactic Similarity of Terms

A5, listed at the beginning of Section 2, deals with the computation of the syntactic similarity of terms. The frequency of terminological occurrence considering the primary terms or some of their synonyms (if needed and available) is obtained following a procedure of matching terms between glossaries. Let's see it observationally with the example of Table 4. As a result of looking at the term name or label, we can state that the term "Project" syntactically matches and thus has full syntactic similarity. Or, we can say that it has an occurrence frequency of 4, simultaneously considering the four glossaries as the target entity to be analyzed. Note that this term does not have synonyms in any glossary, which, if available, are not necessary to be included in the calculation procedure. Once the results of the syntactic frequency were obtained for each glossary term through the tool procedure described in Olsina et al. (2022), we calculated the numbers and percentages shown in Table 6.

Table 6. Metrics and their values for syntactic frequencies (syntactic similarity) of the terms from all four glossaries together

Metric name/acronym/formula	Value
Total sum of primary Terms (TpT)	1,633
Number of Terms with Frequency 4 (#TFq4)	16
Percentage of Terms with Full Syntactic Similarity [%TFSyS = ((#TFq4 * 4) / TpT) * 100]	3.92%
Number of Terms with Frequency 3 (#TFq3)	46
Percentage of Terms with high-Partial Syntactic Similarity [%ThiPSyS = ((#TFq3 * 3) / TpT) * 100]	8.45%
Number of Terms with Frequency 2 (#TFq2)	164
Percentage of Terms with low-Partial Syntactic Similarity [%TloPSyS = ((#TFq2 * 2) / TpT) * 100]	20.09%
Number of Terms with Frequency 1 (#TFq1)	1,103
Percentage of Terms without Syntactic Similarity [%TwSyS = (#TFq1 / TpT) * 100]	67.54%

As represented in Table 6, we designed four indirect metrics (percentages) with their related direct metrics. Percentage metrics calculate the proportion of terms with full syntactic similarity, high-partial syntactic similarity, low-partial syntactic similarity, and without syntactic similarity.

The frequency results were taken from the data processed by the tool, so the values of the base and derived measures are recorded in Table 6. The first direct metric for frequency is the “Number of Terms with Frequency 4”, which resulted in 16. Then, we calculated the “Percentage of Terms with Full Syntactic Similarity”, which is 3.92%. The reader can see the other obtained values for frequencies 3, 2, and 1. Note that frequency 1 implies that a term is either absent from the other three glossaries, or has a slightly different primary term label, with no matching synonyms. Also, note that we have pre-processed some terms such as "Program" and "Programme" for syntactic uniformity. Thanks to this, "Program" has a frequency of 4 instead of 3, since "Programme" is the label used in the APM glossary.

Finally, if we look at the yielded percentages, we can say that the project management glossaries assessed have a low proportion of common terms with full syntactic similarity (16 common terms representing 3.92%) and even with a frequency of 3 (46 common terms representing 8.45%). Considering that since the 1950s, organizations began to systematically apply project management approaches, processes, techniques, and tools to engineering projects, we expected a greater full syntactic match in the glossary terms.

2.6. Calculating Semantic Similarity of Terms

Activity A6 deals with metrics and calculations of categorical semantic similarity based on the frequency of syntactic similarity of glossary terms and their semantic correspondences with designed terminological categories.

Let's apply this activity with the term "Project" shown in Table 4 and exemplified in subsection 2.5, where it turned out to have full syntactic similarity as it has a frequency of occurrence of 4. Also, the definition of "Project" in all four glossaries has a semantic reference to *transient/temporary organization, endeavor, or undertaking*. For this reason, they belong to the conceptual category C8 called “Organizational Entity-, Asset-related Terms”. The reader may notice that the "Project" entry in each glossary has a variation in its definition. However, they are similar considering the categorical keywords, which is why they fall into the same semantic category. Ultimately, we can state that these entries are syntactically and semantically similar and therefore syntactically and semantically consistent concerning the information suitability sub-characteristic defined in Table 1.

Taking into account both the syntactic and semantic aspects of this exploratory study, we have designed a set of direct and indirect metrics whose names and values are shown in Table 7. Note that the formulas for indirect metrics are formulated in Appendix IX at https://bit.ly/C1bSE_Appendices.

On the one hand, regarding the categorical semantic similarities of the 16 terms with a syntactic frequency of 4 (Table 6), only 12 terms have full semantic similarity (#TFSSFq4 = 12). This means that per each common entry, the 4 syntactically equal terms in the 4 glossaries have the same intended semantics as well.

Table 7. Metrics and their values for syntactic frequencies and categorical semantic similarities/discrepancies of the terms from all four glossaries together

Metric name/acronym/formula	Value
Number of Terms with Full Semantic Similarity for Frequency 4 (#TFSSFq4)	12
Number of Terms with high-Partial Semantic Similarity for Frequency 4 (#ThPSSFq4)	3
Number of Terms with low-Partial Semantic Similarity for Frequency 4 (#TlPSSFq4)	1
Number of Terms without Semantic Similarity for Frequency 4 (#TwSSFq4)	0
Number of Terms with Full Semantic Similarity for Frequency 3 (#TFSSFq3)	28
Number of Terms with Partial Semantic Similarity for Frequency 3 (#TPSSFq3)	16
Number of Terms without Semantic Similarity for Frequency 3 (#TwSSFq3)	2
Number of Terms with Full Semantic Similarity for Frequency 2 (#TFSSFq2)	124
Number of Terms without Semantic Similarity for Frequency 2 (#TwSSFq2)	40
Percentage of total Terms with Full Syntactic and Semantic Similarity (%TFS&SS)	2.94%
Percentage of total Terms with high-Partial Semantic Similarity (%ThiPSS)	5.70%
Percentage of total Terms with low-Partial Semantic Similarity (%TloPSS)	17.27%
Percentage of total Terms without any Semantic Similarity (%TwSS)	74.10%

Thus, the Percentage of total Terms with Full Syntactic and Semantic Similarity (%TFS&SS) gives 2.94% from $(\frac{12+4}{1633} * 100)$.

On the other hand, 3 common terms have a high-partial semantic similarity (#ThPSSFq4 = 3), i.e., they have a semantic similarity of only 3 primary terms out of 4. In addition, the Number of Terms with Full Semantic Similarity for Frequency 3 (#TFSSFq3) gives 28. Therefore, the Percentage of total Terms with high-Partial Semantic Similarity (%ThiPSS) gives 5.70% from $(\frac{3*3 + 28*3}{1633} * 100)$.

It is worth noting that for the frequency of 4, there is 1 common term with low-partial semantic similarity, that is, a semantic similarity of only 2 primary terms out of 4. While no term for this frequency has 4 different semantics (#TwSSFq4 = 0).

Table 8. Names of the terms with frequency 4 including the semantic categorization by glossary. Note that a green-colored row indicates full semantic similarity, a yellow-colored row indicates high-partial semantic similarity, an orange-colored row indicates low-partial semantic similarity, and a red one indicates no semantic similarity

Term name or label	PMBOK	APM	IAPM	PRINCE2
portfolio	C8	C8	C8	C9
program	C8	C8	C8	C8
project	C8	C8	C8	C8
project life cycle	C4	C2	C6	C6
project management	C2	C2	C2	C3
project management team	C7	C7	C7	C7
project management office	C8	C8	C8	C8
project manager	C7	C7	C7	C7
quality	C9	C9	C9	C9
report	C9	C6	C6	C6
risk	C4	C4	C4	C4
sponsor	C7	C7	C7	C7
sprint	C4	C4	C4	C4
stakeholder	C7	C7	C7	C7
user story	C9	C9	C9	C9
work package	C6	C6	C6	C6

Finally, Table 8 shows the 16 labels (names) of the project management glossary terms with a syntactic frequency of 4 and their semantic category per glossary, from which the values of the direct metrics in Table 7 were obtained. In addition, Table 8 exhibits a different color for term rows with full, high-partial, low-partial, and no semantic similarity. The reader can see the remainder tables for frequencies 3, 2, and 1 in Appendix X at https://bit.ly/CIbSE_Appendices.

2.7. Analyzing Syntactic and Semantic Consistency

A7 is mainly concerned with the comparative analysis of the syntactic and semantic consistencies of categorized terms. Based on the results of A5 and A6 activities that recorded syntactic and semantic similarities of terms, the detection of consistency issues can be analyzed not only for the four glossaries as a whole but also for the terms within each glossary. Also, many other quality aspects of glossaries could be analyzed.

Firstly, if we look at the glossary term "Project" as a single term designating the intended concept, or "Project" as the word of other compound terms designating related concepts, Table 8 shows 6 common terms (with a frequency of 4) containing the label "Project". If we browse this for a frequency of 3 (see Appendix X of the linked document), there are 3 common terms, while there are 10 common terms for a frequency of 2. However, 91 terms include the label "Project" with a frequency of 1, which imply no syntactic similarity. These figures are a bit surprising taking into account that all the glossaries are for the project management area.

Secondly, if we observe the green-shaded rows for the terms in Table 8, we find 12 syntactically and semantically consistent common terms. That is to say, each one of them shares not only the same label but also falls under the same conceptual category. Therefore, as illustrated in the previous subsection, the common term "Project" is consistent considering the four glossaries. Or, in other words, there is to a large extent a terminological harmonization. But the same is not the case with the common term "Project management", which has a categorical semantic similarity of 3. Table 9 shows its definition in the four glossaries as well as the categories. In Prince 2 this term has process/activity semantics (C3), whereas in the other glossaries it falls into C2. However, in Table 10 we see the term "Project management process" as another related concept existing only in APM and IAPM. So if the Prince 2 term "Project management" had the final word 'process' it would be consistent with that in APM and IAPM.

Table 9. Definitions of the "Project management" term in the four glossaries

Term	Term definition	Gloss.	Cat
Project management	The application of knowledge, skills, tools, and techniques to project activities to meet the project requirements.	PMBOK	C2
Project management	The application of processes, methods, knowledge, skills and experience to achieve specific objectives for change.	APM	C2
Project management	Project management involves *the application of methods and management tools (administration task), *techniques and concepts of leadership (leadership task) and *integration of the competences ... [<i>continues</i>]	IAPM	C2
Project management	The planning, delegating, monitoring and control of all aspects of the project, and the motivation of those involved, to achieve the project objectives within the expected performance targets for time, cost, quality, scope, benefits and risk.	PRINCE2	C3

Table 10. The term "Project management process" is available only in two glossaries

Term	Term definition	Gloss.	Cat
Project management processes	The generic processes that need to apply to each phase of the project life cycle. These may be described as a starting or initiating process, a defining and planning process, a monitoring and controlling process and a learning or closing process.	APM	C3
Project management process	All processes to be performed by the project management team within the scope of a project, including project preparation, project start-up, project implementation (= management of technical planning and implementation) and project close-out.	IAPM	C3

Moreover, the PMBOK term "Project management process group" has a syntactic frequency of 1 with the semantics of process (C3). So if this term had had "Project management process/es" as a synonym or without the word 'group' then it would also have been in Table 10, consistently.

Finally, if we observe the row shaded in orange in Table 8, the inconsistency corresponds to the shared term "Project life cycle" since it has three different semantics.

2.8. Recommending Adoptions and Adaptations

A8 focuses on recommendations for the adoption or adaptation of glossary terms to the new version of the project ontology to be updated, which is located at the core level, as indicated in subsection 2.1. Note that a core ontology should contain generic concepts rather than domain-specific concepts. Thus, if "Project management process" is a generic term, then the term "Agile project management process" is a specialization of it, hence a domain-specific term for a top domain-specific ontology for agile projects. An example of a recently updated core ontology is ProcessCO (Becker et al., 2022).

On the one hand, looking at Table 8, there are terms such as "Sprint" and "User Story" that are rather domain-specific. So they will not be part of the updated project core ontology. Likewise, another term such as "Quality" represents a cross-cutting concept that can be applied to different entities and not only to projects. For this reason, "Quality" was placed in the miscellaneous category (C9). On the other hand, the first eight terms of Table 8 must be considered in the updated project ontology, among others with less frequency of occurrence such as the term "Project management process".

Table 11 shows only four terms, i.e., their labels and definitions of the project ontology developed in 2016. We can make some recommendations in light of the present study.

Table 11. A subset of terms from the project ontology by Rivera et al. (2016)

Term	Term definition	Cat
Project	An entity representing a temporary and goal-oriented endeavor with definite start and finish dates, which considers a managed set of interrelated activities, tasks, and resources aimed at producing and modifying unique work products (i.e., artifacts, services or results) for satisfying a given requester need.	C8
Project life cycle	The series of phases that a Project passes through from its initiation to its closure.	C4
Project management	It is the set of managerial processes and activities intended to achieve the goal operationalized by a project.	C3
Project management plan	The document that describes how the project will be executed, monitored, and controlled.	C6

Regarding the term "Project", the definition made in 2016 can be maintained, since it covers the key concepts given in the four glossaries (see Table 4). We foresee adding the word 'organizational' to the beginning of its definition as "*An organizational entity representing a temporary...*" to explicitly include this C8 keyword.

The term "Project life cycle" was adopted in the first version of the ontology from PMBOK (2013). But the current edition (PMBOK, 2021) rephrases it as "*The series of phases that a project passes through from its start to its completion*", which we will adopt in the new version.

Considering the discussion carried out in the previous subsection for the term "Project management", and taking into account that this term has process/activity semantics (C3) in Table 11, we propose to change the former label to "Project management process" in the new version of the project ontology. Also, we can consider leaving its definition as it is or adapting it a bit. Lastly, for the term "Project management plan" we reused the definition given by PMBOK (2013). The current edition of PMBOK (2021) has the same definition, but only "*... and closed*" was appended to the end of the sentence in Table 11.

In summary, many recommendations can be considered for adoptions and adaptations to the project ontology to be updated, but we are limited in the present analysis for reasons of space. Anyway, we hope that the main aspects of this work have been conveyed.

3. Related Work

To the best of our knowledge, no directly related work in the literature considers a comparative analysis of syntactic and semantic consistency for a set of project management glossaries.

Somewhat related work is Wideman's (2012) glossary on project management, which is comparative and hyperlinked. It contains over 6,400 entries covering over 4,400 primary terms derived from over 200 sources. This glossary was built considering the syntactic similarity of terms. For example, its glossary version 5.5 lists thirty-four definitions of the term "Project". So, the author highlights the preferred definition of it. However, categorical semantic similarity and consistency issues are not taken into account. Note that the glossary version 6.1 was released in July 2017 but is not publicly accessible. Also, it is not used for training and certification purposes.

To search related work in digital libraries, we primarily used Scopus with a variety of keywords and operators, even including glossaries outside the project management area. The result was about 10 articles, which we thoroughly analyzed. Outside the project management area, we found some work related to the software testing domain. Among them, the oldest research was carried out by Arnican et al. (2016). The authors analyzed only inconsistencies in one software testing glossary, without conducting a comparative analysis between terms of different glossaries.

More recently, Tebes et al. (2022) carried out a comparison and analysis of syntactic and semantic similarities and discrepancies between terms of three software testing glossaries for two terminological categories, i.e., for the categories of process/activity and method/technique. Olsina et al. (2022) widened this exploratory

study by considering the label ‘testing’ as a single word or included at the end of a compound label for eight terminological categories. The present work is similar to the approach followed in the two papers cited, but now its steps are explicitly specified. In addition, we deal with another area (project management), so we have redesigned some categories. Moreover, the goal of this exploratory study differs from previous ones.

4. Final Remarks

This paper has shown the results of analyzing the syntactic and semantic similarities and consistencies between terms of four selected project management glossaries documented in PMBOK (2021), APM (2021), IAPM (2021), and PRINCE2 (2017). We have supported this comparative analysis by using a set of metrics in addition to a set of conceptual categories which helped us to semantically categorize all glossaries' terms.

We have established in Section 2 the list of activities that systematically guided us in the execution, discussion, and documentation of the present study. As an end goal, this exploratory study will help us to examine in a more disciplined way our previously developed project ontology and recommend adoptions and adaptations from glossaries, as described in subsection 2.8. Additionally, the comparative analysis has permitted us to assess the level of syntactic and semantic consistency and harmonization existing in the selected glossaries.

In a nutshell, what has become evident from this early research on project management glossaries is that there are many opportunities to improve these terminologies to achieve greater consistency, harmonization, and standardization in the field.

As for a threat to the validity of this exploratory study, particularly for a task from activity A4 (Put glossary terms into categories taking into account the semantics intended by glossary authors in their definitions), we cannot guarantee the absence of miscategorizations in the process of placing the terms in the proper category. Although category names or labels have a set of well-defined keywords (see Table 3) that, after reading a given term definition, guide the process of identifying the term semantics by a human agent, term definitions are often not well structured. For example, in some cases, the term starts with a note and then comes with some kind of definition. Or, rarely the definitions of terms are structured by using the hypernym-hyponym relationship.

Faced with this situation, in future work, we will explore the sub-characteristics and attributes of information quality that can be considered for the evaluation and comparison of glossaries, such as syntactic correctness, semantic correctness, and non-redundant coverage, among other aspects of quality.

Ultimately, in the short term, we will update the project core ontology mentioned above.

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