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Research article

Empowering end users in the development of terminological ontologies to further sustainable digital solutions

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This article explores an innovative approach to developing terminological ontologies by actively involving end users. The study outlines the methodology, presents results from a pilot study, and discusses the implications for promoting data-driven cultures and sustainable digital solutions. In particular, we propose an inclusive user-centred approach to building terminological ontologies, which may serve as a semantic layer of a data catalogue. A pilot study is presented, in which participants were given a sequence of three simple tasks conducted in a (non-invasive) controlled experimental setting uncovering conceptualizations in a natural business context. The pilot study shows that within a short time frame, it is possible for participants to produce relevant domain-specific terminology which may start the subsequent drafting of a terminological ontology. Moreover, effective dual-mode visualizations of terminological ontologies combining textual and graphical formats may enable end users in the further expansion and quality assurance of ontologies.

Keywords: user-centred approach, domain-specific terminology, terminological ontologies, dual-mode visualizations

Responsabiliser les utilisateurs finaux dans le développement d'ontologies terminologiques pour promouvoir des solutions numériques durables

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L'article explore une approche innovante pour développer des ontologies terminologiques en impliquant activement les utilisateurs finaux. L'étude décrit la méthodologie de cette approche inclusive centrée sur l'utilisateur, présente les résultats d'une étude pilote et en discute les implications pour la promotion de cultures axée sur les données et de solutions numériques durables. Les ontologies terminologiques ainsi développées peuvent servir de couche sémantique pour un catalogue de données. Dans l'étude pilote présentée, les participants ont reçu une séquence de trois tâches simples menées dans un cadre expérimental contrôlé (non invasif), qui consistaient à découvrir des conceptualisations dans une négociation d'affaires naturelle. L'étude pilote montre qu'en peu de temps, il est possible pour les participants de produire une terminologie pertinente et spécifique à un domaine donné, ce qui peut permettre de commencer la rédaction ultérieure d'une ontologie terminologique. En outre, des visualisations plus efficaces des ontologies terminologiques – des affichages double mode combinant des formats textuels et graphiques – peuvent permettre aux utilisateurs finaux à la fois d'étendre les ontologies et d'en assurer la qualité.

Mots-clés : approche centrée sur l'utilisateur, terminologie spécifique à un certain domaine, ontologies terminologiques, affichages double mode

1 Introduction

Sustainable digital solutions with a lasting impact enabling data-driven decision-making in organizations require a close connection to end users. The empowerment of end users in ontology engineering is essential for leveraging domain expertise, improving the relevance and accuracy of terminological ontologies, and thereby reducing development cycles, lowering costs, and/or bridging the gap between IT and business (Sanctorum et al., 2022). This can also be seen as sustainability in an "economic sense" bridging the gap between data consumers and producers in addition to sustainability in a "social sense" providing users access to information and communities, where sustainability is seen as a "catalyst for inclusiveness in our over-increasingly digitalized world" (Bork et al., 2024). Therefore, the empowerment of end users is necessary to improve the overall data pipeline processes (Munappy, Bosch & Olsson, 2020) and further the development and utilization of AI (Esposito et al., 2023). In other words, a more collaborative and user-centred approach has the potential to ensure accurate terminology ontology engineering and better terminology of business domains, which is essential for efforts and strategies pursuing sustainable digitalization.

At the same time, there is a growing need for simpler, more user-centred methodologies, where the need for ontology engineers is reduced (De Nicola & Missikoff, 2016). The pilot study presented in this article is partly inspired by earlier user-centred research proposing the so-called "UPON Lite" method. In particular, UPON Lite represents a rapid method for ontology building which engages and includes domain experts, while reducing the role of and dependency on ontology engineers until the final step of formalization (De Nicola & Missikoff, 2016). Hence, UPON Lite shifts the responsibility for ontology building toward a community of end users through a social, highly participative approach. In our research, we apply the main principles of this systematic, rapid, and user-centred approach comprising an ordered set of five steps into the field of terminology by proposing three corresponding exercises uncovering end users' conceptualizations with the purpose of the subsequent drafting of (formalized) terminological ontologies. The terminological ontologies will be visualised in a data catalogue but may also be used in the inference and formulation of definitions as well as mapping and connecting terminology to data elements.

Before outlining and applying the proposed user-centred approach to terminological ontology engineering, a clear understanding of key concepts is necessary: "User-centred" simply means putting the end user at the centre of the design process, where

the “end users” constitute a broad group of domain specialists of any business domain, expertise level, native language as well as other professional or personal backgrounds. In addition, end users match a data-catalogue use-case with a need to query, search and acquire knowledge about data. The sequence of exercises is conducted in a controlled experimental setting assembling a laboratory for exploring human cognition and conceptualizations, which is called “the Lab”. However, the Lab is highly flexible and “non-invasive” in the same sense as e.g. Seiner (2014) introduced the concept into business-friendly data governance. Hence, the Lab can be established in any locations in the organization close to participants every-day business life. The non-invasive (and rapid) method is expected to support an un-biased, inclusive user-centred setting preparing for the subsequent terminological ontology building.

“Terminological ontologies” can be defined as the explicit (or formal) specification of a conceptualization (Gruber, 1993) and may be described as a form of “advanced terminological concept system” where the specification of characteristics is included (Christensen & Madsen, 2023). Hence, terminological ontologies serve the purpose of systematically organizing and representing the terminology belonging to a specific domain or subject area, and definitions can be inferred from these formal specifications of characteristics (Madsen & Thomsen, 2009). It should be noted that initially we focus on the most important dimension of each concept, but several (multiple) dimensions of terminology shaping the associated conceptualization may arise when more end users are involved, which will require the future incorporation of multidimensionality (Bowker, 2022).

We perceive a “data catalogue” as a form of terminological resource serving as the semantic layer of a central metadata repository of an organization’s data assets (ISO, 2004), and thus providing end users’ access to information and communities as well as bridging the gap between data consumers and producers (Bork et al., 2024). Terminological ontologies will prove valuable throughout the disciplines of the data pipeline including the phases of data collection, data storage, data discovery etc. – as well as at the various levels of end user data literacy (i.e. from the weakest data beginner to the strongest data scientist). In addition, terminological ontologies may fulfil aspirations arising from data governance, data management or data enablement strategies aiming at promoting sustainable data-driven cultures, processes and tools (Kremser & Brunauer, 2019). It has been argued that the need for various types of end users to become more familiar with the data of their domains has given rise to data

catalogues (Ehrlinger et al., 2021), in which a linguistic glossary component allows for the collection of and access to the specialized vocabulary (i.e. business and data terms, consistent definitions, and related terms) of the most important data assets of an organization. Indeed, an extensive literature in the subfields of data exists, and it lies beyond the scope of this article to review this body of literature, and therefore, only the research most relevant to the field of terminology are included.

The aim of this article is to explore whether a sequence of three terminological exercises conducted by potential end users (of a data catalogue) in a controlled experimental setting (the Lab) will render possible the subsequent drafting of a terminological ontology, which may be visualised in textual and graphical formats and thereby serve as a semantic and searchable component of the data catalogue. Earlier research aimed at analysing end users' expertise and cognition of terminology (Nielsen, 2015) combined with research proposing light-weight ontology engineering (De Nicola & Missikoff, 2016) has guided the experimental design.

The article is organized as follows: In section 2, we outline the methodology of terminology as a field bridging both linguistic and conceptual dimensions of human knowledge to be uncovered by simple exercises and used in the subsequent drafting of terminological ontologies. In section 3, we present the design of a user-centred experimental approach to the building of terminological ontologies and describe the experimental setting of the pilot study including participants, exercises and timeframes. In section 4, we present our results and continue with the analysis of one participant's response, proposing the drafting and visualization of terminological ontologies into textual and graphical formats. In section 5, we discuss implications, including the subsequent scaling, perspectives and future directions of research concerning the user-centred approach. In section 6, we finalize the article with concluding remarks, and references are listed in section 7.

2 Methodology: Uncovering End Users' Terminology

The methodology of our research rests on the field of terminology which is outlined and combined with terminological ontology engineering (see Section 2.1) and visualization (see Section 2.2).

The term "terminology" is sometimes confusing as it constitutes a homonym designating three different concepts (Cabré, 1999): Firstly, a terminology can be a vocabulary (set of

terms) belonging to a subject field. Secondly, terminology is a practice (set of guidelines) of terminology work including the discipline of concept clarification. And thirdly, terminology constitutes a field of science (set of theories) studying the knowledge and practice of terminology. In this article, we are applying all three aspects of terminology, as the participants of the pilot study produce terminology (a set of domain-specific terms); the drafting of terminological ontologies requires sound concept clarification methodology following terminology guidelines; and finally, the proposed user-centred approach contributes with new knowledge in the field of terminology science.

Each term constitutes a terminological unit containing three theoretical dimensions, and it should be noted that no particular order is required in the analysis of these dimensions of the terminological units (Cabré, 2003): The communicative dimension requires terms to be existing in an authentic specialized discourse produced or promoted by subject matter experts. The linguistic dimension means that terms are lexical units of a (mono-, bi- or multilingual) specialized language. The conceptual dimension, where terms designate an underlying unit of a specialized and shared knowledge resulting from the conceptualization process of language users. And according to Nilsson (2023), we may add that the term "concept" in terminology and terminology work refers to a non-linguistic thought or knowledge unit, which contains a collection of characteristics (the concept's intension) that covers a certain category of referents in reality (the concept's extension).

In this light, it is imperative to develop experimental methods and settings which in a simple and straightforward way supports the end users in tasks which reflect the shared knowledge belonging to business domains. Overall, and compared to earlier research (Nielsen, 2015), the experimental setting (the Lab) is far more business-friendly due to the empowerment of any potential end user spending less than an hour in a non-invasive setup in which all expertise and domains are relevant.

2.1 Terminology and Ontology Engineering

Earlier user-centred research exploring domain-specific terminology and terminological ontologies has developed exercises aimed at measuring expertise levels of end users, including tasks of recalling, categorization, reading, searching and card sorting (Nielsen, 2015). These tasks were conducted in a quite different experimental setting using a printed background questionnaire hand-outs answered prior to an eye-tracking experiment, which was conducted in a cognitive eye-tracking lab and followed by a final

experimental debrief and retrospective interview, as well as later and follow-up focus-group discussions. This previous research showed no clear or significant expertise effects due to a number of experimental weaknesses, which overall made it difficult to demonstrate a superior performance of experts (Nielsen, 2015). However, some of the exercises are reused and refined in our pilot study. Hence, in the pilot study presented below (see Section 3 and Table 1) three of the earlier exercises are fitted into the stepwise UPON Lite setting (later) proposed by De Nicola & Missikoff (2016), where participants now are asked to use their own domain-specific terminology when they conduct the experiment and individual levels of expertise is no longer of primary research interest. Moreover, the pilot study will show how this earlier research on user-centred ontology drafting (UPON Lite) may be applied to the special case of terminological ontologies.

In particular, the three proposed exercises of the pilot study reflect the three formal criteria for identifying terms (Cabré, 2003): The first exercise is about recalling and writing down terms from which we may identify the lexical units of the subject area. The second exercise is about describing the meaning of the terms and here the response will reflect knowledge and characteristics of underlying concepts. The third exercise is finally a sorting exercise, where the underlying concepts are further subdivided and structured. Overall, these three exercises constitute the three criteria for terms which are identified in specialized language (as lexical units), specialized discourse (as communicative units) and as specialized concepts (unit of knowledge). Hence, the three exercises hold the potential of starting the process of terminology ontology drafting as the experiment produces core components of ontology engineering.

2.2 Terminology and Ontology Visualization

Earlier research has demonstrated how terminological ontologies may be visualised in a dual format combining the lexical (i.e. textual) dimension of terms with the conceptual (i.e. graphical) dimension (e.g. Nielsen, 2015). This means that it is possible to combine a word-oriented (lexicographic) format with a (terminological) concept-oriented (Madsen, Thomsen, Halskov & Lassen, 2010). Moreover, earlier research has demonstrated effective and increasing performance (learning effects) on experiments containing questions related to diagrams displaying sub-ontologies across all participants and expertise levels (Nielsen, 2016). Therefore, it has been concluded, that the visualizations of concepts by means of terminological ontologies should be part of

the user interface of terminological resources (including data catalogues) as it is demonstrated that users were able to acquire knowledge from the graphical format.

This means that effective dual-mode visualizations of terminological ontologies combining textual and graphical formats may likewise support and enable end users of the data catalogue to query and engage in the continuing improvements of the terminological content. In particular, modern terminology and data catalogue tools support many different formats and structures, providing end users with access to both textual and graphical content formats. This means that a glossary of terms (i.e. domain terminology) could be presented as a systematic list of terms with textual definitions of the designated concepts including a link to the underlying terminological ontology presented as graph.

3 Experimentation: Uncovering End Users' Terminology

In this section, the experimental setting of the pilot study is outlined beginning with the controlled experimental setting in which participants of the pilot study conduct the sequence of exercises (see Section 3.1) followed by a description of and motivation behind each of the three exercises (see Sections 3.2-3.4).

3.1 User-centred Terminological Experimentation

We propose a user-centred approach starting the process of terminological ontology drafting. The approach is inspired by earlier research proposing the UPON Lite method (De Nicola & Missikoff, 2016) comprising of five exercises (steps), which we transform into three exercises (see Table 1).

Table 1. A user-centred stepwise approach to drafting terminological ontologies

	Step 1	**Step 2**	**Step 3**	**Step 4**
UPON Lite	Lexicon (Step 1)	Glossary (Step 2)	Taxonomy (Step 3) Predication (Step 4) Parthood (Step 5)	Ontology (Step 6)
Pilot study	Recalling expressions (Section 3.2)	Describing meaning (Section 3.3)	Sorting structures (Section 3.4)	Drafting terminological ontology (Section 4.1)
Terminology	Terms (Designations)	Concept definition	Concept relations	Formal specification of conceptualization

A controlled experimental setting (the Lab) is established on-site the organization and participants are bringing their own laptops to produce (and return) their written response. In this first pilot study, three participants have been invited to conduct the experiment at the same time but are asked not to engage in any conversations during the course of the experiment. Thus, three voluntary data specialists were invited into the Lab and given the three exercises each lasting 15 minutes. As part of their invitation, they have received a file (i.e. an Excel spreadsheet) containing information needed: The spreadsheet consists of five tabs, a brief introduction containing examples of terminology from the taxation domain followed by three small exercises and concluded with a series of feedback questions about the experiment. The exercises are further described below (see Sections 3.2-3.4), and the answers were later used to draft and visualise terminological ontologies (see Sections 4.1-4.2).

It is crucial that participants are in a quiet and undisturbed space where they can concentrate fully on contemplating concepts related to their field and complete each exercise within the fixed timeframe. During this process, the experiment leader may assist with any questions or uncertainties that may arise. The experiment should be finalized with a debriefing session, inviting participants to provide feedback and engage in further conceptual work at a later point in time.

Setting up the Lab close to the users, rather than having users visit a researcher's cognitive laboratory at university (which can be far from their natural working environment in a company or organization), provides maximum flexibility. The Lab can be established promptly as needed or requested by users. Additionally, as many participants as relevant can take part, and they need not necessarily be closely related

in terms of field of domain. Moreover, the Lab can also be set up for subsequent iterations, resuming conceptual work based on previous responses.

Participants are professionals (i.e. staff members in the organization) and potential end users of a data catalogue, and they constitute experts within a specific field such as legal, economic, or administrative, and with a need to seek knowledge about data. Professionals typically work in one or more domains and thereby contribute to the field by actively using and developing terminology as active members and contributors to a knowledge field. However, expertise is a complex and cognitive dimension that is not exclusively reflected by educational background or current employment. For example, not all employees in tax administration are tax experts, and not all tax experts are employed in tax administration (Nielsen, 2015). In large organizations, business areas often encompass multiple professional domains. Therefore, it is crucial to illuminate the professional fields within a business area by involving many various types of professionals, regardless of their individual expertise or professional prerequisites within one or more relevant disciplines. Professionals may assist in terminology extraction by identifying central sources and primary terms that terminology extraction can build upon. Combining the experimental exercises with terminology extraction and subsequently convening for a collective review and consolidation of answers and term candidates forms the basis for conceptual terminology work.

The time frame for each exercise is 15 minutes. In the pilot study, we counted the number of responses after 5, 10 and 15 minutes (see Table 2).

Table 2. Number of terms in each exercise of each participant in the pilot study after respectively 5, 10 and 15 minutes

	Exercise 1: Recalling expressions	**Exercise 2: Describing meaning**	**Exercise 3: Sorting structures**
Participant 1	16; 29; 32	4; 8; 12	N.a.; n.a.; 11
Participant 2	12; 19; 24	4; 9; 13	6; 9; 18
Participant 3	20; 40; 43	9; 12; 19	5; 18; 21

It is important to keep participants alert and focused during the entire time frame. Earlier research shows that the total time frame of an experiment should be kept at a minimum (Nielsen, 2015) and with the three exercises including instructions and answering (to be performed in an Excel spreadsheet), the total completion time of the entire experiment is kept under one hour.

In the pilot study, all three participants were able to produce a list of terms from different self-selected domains. In particular, participant 1 chose occupational insurance of the labour market as domain, participant 2 chose analytics and participant 3 chose housing support. And it appears from the pilot study that 15 minutes strike a good balance – not too short and not too long. In addition, a discussion session with participants after the pilot study revealed that 15 minutes seemed to balance off the need for focus on the one hand with the need for a sufficient time for brainstorming (exercise 1) as well as analysis of meaning (exercise 2) and structuring (exercise 3), on the other hand.

It should be noted that only a minimal introduction was given. The field of terminology as well as the criteria defining and delimiting terms as something distinct from concepts is often confusing for laymen and introductions should be kept simple. At the same time, we should avoid giving too many examples which may very well distort or contaminate participants' responses (Nielsen, 2015). The pilot study shows that participants are fully capable of performing the exercises with the scarce introduction (see Table 2). Of course, in the debrief and in subsequent drafting of terminological ontologies in later workshops with end users, a solid introduction and explanation of terminology is given.

3.2 Exercise 1: Recalling expressions (Listing terms)

In the first exercise participants are given the following instruction (in Danish): "Write down the key specialized terms related to your field that you can think of. Feel free to expand the list below if needed. You have approximately 15 minutes for this exercise." The exercise is solved by listing the words and expressions that come to mind in the relevant tab of the provided spreadsheet, while the experimenter starts the timer.

In earlier research aimed at measuring potential end users' expertise and their cognitive processing of dual-mode visualizations of terminological ontologies, 40 participants were likewise asked to list up to ten specialized terms within the taxation domain, but without any given time limit (Nielsen, 2015). All 40 participants recalled at least seven terms, and 28 participants completed a complete list of ten terms. Overall, the participants generated a total of 377 terms, of which 177 are unique terms, and 115 terms are mentioned by only one participant. Simultaneously, the same term can be mentioned by up to 17 participants. It will also become evident that not all terms express (designates) concepts that can definitively be associated with the required field of taxation.

In relation to the earlier research, we impose a strict time limit of 15 minutes but there are no demands pertaining to domain or maximum number of terms. The deadline creates some pressure, prompting participants to think carefully and thoroughly. On the other hand, participants do not encounter an upper limit on the list as they are free to think and produce as many terms as they can recall. In the pilot study, a pattern emerges where participants generate somewhere between 20 and 40 terms, and the majority of the list is typically completed within the first 10 minutes (see Table 2).

In the pilot study, situations arise where a participant is unsure how to express a term. This occurs when a participant, somewhat frustrated, suddenly exclaims something like, 'What's that called again?' Moreover, we also discover that participants do not limit themselves to their native language (Danish) but often resort to English as a foreign academic or professional language to express their expertise even in an organization, where Danish is the predominant working language.

In this context aimed at the drafting of terminological ontologies capturing the conceptualization of a domain, a free exercise is better for individual inventiveness, productivity, and creativity than having words and expressions selected from a predefined list, as was the chosen design of the UPON Lite method (De Nicola & Missikoff, 2016). A task of running through a predefined lists pose a risk of influencing participants by others' associations instead of following one's own, which ensures a comprehensive exploration of all corners and dimensions of a domain. Moreover, in earlier research on a task of categorization (see Section 3.3) where participants were asked to browse a list of specialized terms combined with constructed lexical units resembling existing terms (so-called pseudo-terms), participants tend not to believe in the existence of existing specialized terms compared to the constructed lexical units (Nielsen, 2015).

When the exercise is conducted in full scale as a recurring event in the Lab, future research will show whether the responses and behaviours from the pilot study regarding the listing exercise is confirmed or new insights will appear. In particular, it is necessary to engage in dialogue with selected target groups that can represent further relevant perspectives and contexts around the resulting terminology.

3.3 Exercise 2: Describing Meaning (Defining Concepts)

The list of terms in the first exercise is not independently evaluated before the second excise begins. The next exercise invites participants to revisit and evaluate their proposed list by carefully considering the meaning of each proposed term. It should be noted that the written lists, combined with descriptions of meaning and systematic sorting structures, serve as a solid foundation for conceptual work underlying the subsequent drafting of terminological ontologies.

In the second exercise participants are given the following instruction (in Danish): ”For each of the specialized expressions you wrote down in exercise 1, briefly describe the meaning of each expression. You should not modify exercise 1, but feel free to add new specialized expressions if needed. You have approximately 15 minutes for this exercise.” In the pilot study, all three participants were able to describe the meaning of (the underlying concepts of) a proportion of the proposed terms listed in the first exercise (see Table 2). It comes as no surprise that it is far more time consuming to analyse the underlying conceptual content of terms than to simply list the designations.

What appears to happen is that when participants revisit their initial list of terms to describe meanings, they realize that in the first exercise, they overlooked something that needs to be added. It boils down to the fact that these concepts are interconnected, which becomes evident when describing the meaning. Concepts consist of characteristic features that distinguish them from other concepts within a field, and this process allows participants to discover the concepts they missed in the first listing exercise. Describing the meaning of the proposed designations is time consuming, and participants are not expected to complete the entire list. However, this doesn’t impact the experiment itself, as the responses are not evaluated independently but are carried forward into subsequent conceptual work. Hence, any gaps or ambiguities will be cross-checked with other responses and discussed with participants at a later point in time.

The second exercise of the pilot study was partly developed from earlier research (Nielsen, 2015), in which 40 participants were asked to describe the meanings of specialized terms they believed existed, based on a predefined list containing existing specialized terms from the taxation domain as well as constructed lexical units sounding plausible and also resembling the spelling of existing terms. Apart from a few exceptions, the quality of descriptions of meanings were poor and the trust in existing terms turned out weak. Still, the exercise is a fruitful way of getting participants to describe meaning,

which may support the drafting of terminological ontologies and thereby the inference of definitions. The latter follows a standardized discipline to infer and formulate concept definitions (e.g. ISO, 2022).

When the pilot study is conducted in full scale, future research will show whether the responses of the defining task describing meaning of the underlying concepts is confirmed or new insights will appear. In particular, a risk of a quality issue in the descriptions may arise, disturbing the subsequent drafting of terminological ontologies.

3.4 Exercise 3: Sorting Structures (Subdividing Concepts)

In the third and final exercise participants are given the following instruction (in Danish): "Now, for each of the terms you suggested in exercises 1 and 2, sort the structures of the expressions in relation to each other in a systematic order. You should not modify exercise 1 and 2, but feel free to add new specialized terms if needed. You have approximately 15 minutes for this exercise."

In the pilot study, all three participants were able to structure a large part of the expressions produced in the previous exercises 1 and 2 (See Table 2). However, this exercise is by far the most difficult for participants to comprehend and decide how to answer in the provided spreadsheet. The third exercise of the pilot study was (also) developed from earlier research (Nielsen, 2015), in which nine participants were given a card-sorting task, where they were asked to draw a diagram (on paper) consisting of 32 designations. On average, they had 31.3 designation per drawing, ranging from 21 designations (lowest) to 49 (highest). In addition, participants have, on average, drawn 19.2 relations per drawing, ranging from 5 (lowest) to 46 (highest).

The third exercise primarily aims to create a first structure which can be used to the subsequent subdivision and formal specification of concepts into terminological ontology drafting. No specific format is required in the exercise, so participants are entirely free to illustrate the systematics as they prefer. However, this third and final exercise tends to be the most challenging for participants to understand and execute. The three participants all introduce numbering and follow the principles guiding a table of contents in which superordinate concepts receive prominent placement with associated subordinate concepts listed below in separate rows. This listing format means that superordinate concepts lack interconnectedness, and typically, no more than one or two layers of subordinate concepts are covered. Some participants lose

track, leading to repeated use of certain terms and immediate weakening of the systematic approach. It should be noted that an exercise of card-sorting or knowledge structuring is multifaceted and far from easy for participants conducting the task, as many perspectives and features of specialized language and terminology (Hjorland & Gnoli, 2022) may emerge during the exercise.

When the pilot study is conducted in full scale future research will show whether the nature of the exercise as well as the response format of the structuring task is well working and making it possible for participants to produce useful responses. It may become necessary to provide paper and pencil for this structuring task, if the spreadsheet proves too difficult to use. The responses will be revisited with the participants, combining and cross-referencing across systematic lists during subsequent workshops discussing first version drafts of terminological ontologies.

4 Results: Drafting and Visualising Terminological Ontologies

In this section, the results of the pilot study are presented by analysing one of the three participants' responses. We first describe the drafting of terminological ontologies using this response from one participant (See Section 4.1) then we recommend a dual-mode visualization relevant for terminological resources such as data catalogues to support end users and to further enrich future content (See Section 4.2).

4.1 Terminological Ontology Drafting

One of the most recent studies explaining the principles underlying the method of terminological ontologies is Christensen & Madsen (2023). It follows that when domain-specific terminology is being uncovered, we need to consider all three dimensions of terminology (see Section 2): In the exercises of the pilot studies, the chosen participant produces a structure of knowledge, where concepts, relations and characteristics are expressed by means of linguistic units from which a terminological ontology can be drafted (see Table 3).

Table 3. Answer of exercise 1, 2 and 3 by a chosen participant 1

Response to Exercise 1: 32 expressions listed	**Response to Exercise 2: 12 meanings described**	**Response to Exercise 3: 11 structures sorted**
erhvervsevne	erhvervsevne	1 AES
mén	arbejdsskade	1.1 Arbejdsskadesager
arbejdsskade	erstatsningssag	1.1.1 Nye sager
erstatsningssag	erhvervssygdom	1.1.1.1 Lægeerklæring 1
diagnose	revisionssag	1.1.2 Genoptager
erhvervssygdom	henvisning	1.1.3 Revisioner
ulykkesade	ændringssag	1.1.3 Henvisninger
branchegruppe	midlertid afgørelse	1.1.3 Ændringer
genoptagelsessag	lægeerklæring 1	1.2 Private erstatningsager
revisionssag	anmeldelsesdato	1.3 Erhvervsevnetab
henvisninssag	tilskadekomne	1.4 Mén
ændringssag	principafgørelse	
midlertid afgørelse		
méngrad		
lægeerklæring 1		
anmeldelsesdato		
tilskadekomne		
principafgørelse		
forudbestående sygdomme		
konkurrende sygdomme		
stationær skade		
anerkende (eller afvise en sag)		
kompleks sag		
méntabellen		
lægeligt dokument		
symptomgivende		
udstrålende smerter		
lønskema		
arbejdsevne		
brosymptom		
varige skader		
forsikringsselskab		

The exercises render possible the drafting of a terminological ontology consisting of all 11 concepts structured in the final exercise 3 (see third column of Table 3). It should be noted that the exact numbering in the response is somewhat confusing, however, in the response spreadsheet, the structure was clearly indicated by the participant as indentation was used, which provided us with the necessary subdivision structures. In this case, it is important to structure and add characteristics (so-called subdivision criteria) as well as relations between the concepts (Christensen & Madsen, 2023). Let us show an example demonstrating the first steps of terminological ontology engineering based on the response from participant 1:

We identify the superordinate concept from the exercises (i.e. 1. *arbejdsmarkedets erhvervssikring*, which may translate into 'occupational insurance of the labour market') and the two (first) subordinate concepts (i.e. 1.1 *arbejdsulykke*, which may translate into 'workplace accident' and 1.2 *erhvervssygdom*, which may translate into 'work-related illness') belonging to the same subdivision criteria (i.e. *hændelse* which translates into 'incident') with relevant delimiting characteristics. The terminological ontology may be visualised and presented in the graphical format (See Figure 1).

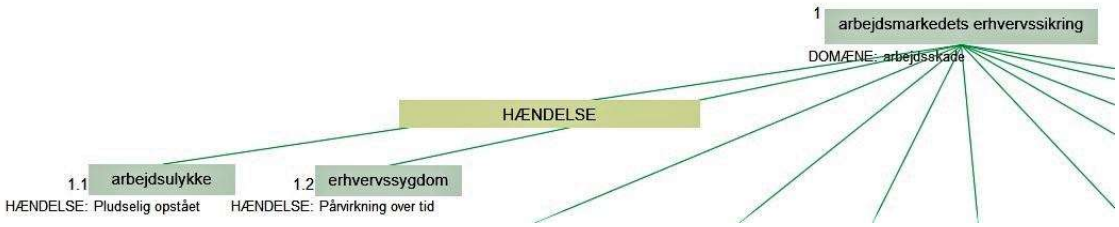

Figure 1. Example of the first corner in the graphical format of a terminological ontology based on the response produced by participant 1.

From these first steps it is possible to expand the terminological ontology further by means of analysing and revisiting the responses on the three exercises. In total, it is possible from the material produced by Participant 1 to draft a three-layer terminological ontology consisting of 18 concepts and 8 subdivision criteria. Of course, further validation will be needed from domain experts as well as domain discourse and/or (generative) artificial intelligence such as chatbots and large language models.

Definitions may be thought of as "verbal explanations" which can be extracted from the formal specialized discourse (Nielsen, 2015). However, it is possible to infer consistent definitions of concepts from the formal specifications of the terminological ontology (Christensen & Madsen, 2023; Nielsen, 2015; ISO, 2004; 2019 and 2022). The work of defining concepts should be continuously prioritized and revisited with domain experts, as well as based on further term extraction from specialized texts. Terminology work is, in other words, iterative and dynamic, and it should never come to a standstill, and it must be ensured that processes and tools support the dynamic nature of terminology. At the same time, we should strive for maximum quality, stability, and sustainability in terminology work.

4.2 Terminological Ontology Visualization

It is widely recognized that effective visualizations of ontologies vary. In particular, Madsen, Thomsen, Halskov & Lassen (2010) argue for a convergence between lexicography and terminology, which allows for inserting (concept-oriented) encyclopaedic or lexical-semantic knowledge into a (word-oriented) user interface. Therefore, terminological ontologies allow for the effective visualization of concepts, relations and characteristics in the graphical format, which will further end users' acquisition of domain-specific terminology and knowledge (Nielsen, 2016). And with the use of databases, the possibilities for presentation no longer depend solely on the structure of the data collection, and thus it is possible to present data from a concept-oriented structure in a word-oriented user interface (Nielsen, 2015).

The exercises in the Lab demand no end user prerequisites, neither in terms of time frame nor knowledge of terminology, but, as shown in the previous section, the approach contributes to the first drafting of terminological ontologies. It should be noted that the process of building, validating and enhancing a high-quality ontology (See Figure 1) or glossary (See Figure 2) enabling end users to adopt data-driven cultures, requires that end users are empowered and plays a part in the development process as early as possible, and that requires user-friendly visualizations.

ID	Term	Definition
1.	Arbejdsmarkedets Erhvervssikring	domæne, som håndterer arbejdsskade
1.1	arbejdsulykke	arbejdsskade, som er pludselig opstået
1.2	erhvervssygdom	arbejdsskade, som er opstået fra påvirkning over tid

Figure 2. Example of the glossary pertaining to the first corner of terminological ontology presented in the graphical format in Figure 1.

Earlier research (Nielsen, 2016) has shown that any user, independent of expertise level, is able to retrieve knowledge from subontologies, and moreover, participants demonstrate significant learning effects in processing a dual-mode visualization (Nielsen, 2015 and b). This means that combining the textual and graphical visualization is recommended. In this light, the pilot study constitutes a two-step iteration, which is set off with a first end user engaging phase comprising exercises as the basis for drafting terminological ontologies and continues into a second phase with the visualization into preferably both textual and graphical formats as the basis for subsequent iterations engaging an increasing number of end user types:

In the future uncovering of end users' terminology, it will be crucial to have the ability to clarify concepts using different approaches. The reason is that conceptual work in a business domain is often complex and can encompass various fields and professional communities, which is influenced by diverse cultures. Consequently, it will be necessary to switch between the linguistic expression side of a concept (i.e. from concept to term) and the meaning side of a concept (i.e. from term to concept). Linguistic expressions may appear similar (homonyms) but carry different meanings. Conversely, linguistic expressions may have the same meaning (synonyms) but appear different. Moreover, when working with multilingual contexts, different languages (e.g. Danish and English) may be used simultaneously. Throughout the conceptual work, expressions and meanings are continuously aligned until a sufficiently precise and stable semantic coherence is achieved.

5 Discussion: Implications and Future Perspectives for Sustainable Digital Solutions

Sustainability of digitalization is about escaping biases by representing as many of the multifaceted dimensions of end user needs as possible. In particular, a specialized discourse holds several dimensions of terminology (Nielsen, 2015) – and it is important to avoid any exclusion of any types of end users. On the contrary, end users bring a broad variety of knowledge, expertise and terminology into the experiments. A previous study on experimental terminology and knowledge dissemination shows that expertise relates to many various dimensions from the relevant domain participation, motivation, exposure and education (Nielsen, 2015). Therefore, an inclusive and dynamic approach is needed, where ontologies and glossaries developed from the first round of exercises should be of the best quality before being shared, but they should likewise be made ready for further development and expansion as new terminology is made available from new experiments.

The pilot study shows that end users of terminological resources, including data catalogues, may be empowered to start the process of drafting terminological ontologies by conducting simple exercises and spending less than one hour in the Lab. The three participants selected random subject fields and produced responses that were ready to start or enrich terminological ontologies, and overall, the method seems to be highly independent of participants' expertise and domains, which therefore holds the potential of continuously ensuring both depth and breadth of the terminological ontologies (Nielsen, 2015).

It is likely that the first term (or concept) that comes to end users' minds in the exercises conducted in the Lab, may very well be closely related to the term, concept or data searched for in the data catalogue, and that may very well guide the further development of the data catalogue. In particular, future iterations are necessary to ensure quality of the terminological ontologies as well as the mapping to data elements in the data catalogue: Firstly, we need expert end users to fill potential holes in structures, solve conflicting responses or conceptualizations as well as assist on the mapping. Secondly, more end users are needed as the scaling proceeds covering various expertise levels as well as more domains. Thirdly, data end users should be recruited into the development of data catalogues.

As the pilot study shows, participants were able to come up with largely diverse domains (See Section 3). This means that any field of knowledge (i.e. academics, linguistics, semantics, analytics etc.) is relevant. In addition, specialized discourse comprises many types of knowledge-structuring methods – the pilot study shows possibilities of integrating the exercises along other types of user-centred approaches: The experimental approach may well stand on its own but may just as well be integrated with user-centred innovation processes or problem-solving disciplines producing conceptual models, which may contribute to the clarification of core concepts and hence bring together corner stones of digitisation efforts.

To sum up, multifaceted views are needed to ensure sustainable digitalization, and the proposed innovative and inclusive user-centred approach empowering end users across any level of expertise and business domain bridges gaps between data consumers and producers (economic-sense sustainability) and provides access to information and communities (social-sense sustainability), overall improving the lasting impact digitalization efforts and solutions.

6 Conclusion

The aim of this article was to explore whether an innovative approach comprising a sequence of terminological exercises uncovering end users' terminology was able to start the process of drafting and visualizing terminological ontologies. The pilot study was to a large extent inspired and guided by learnings from earlier research on user-centred ontology drafting (UPON Lite) where it may be concluded that the method also applies to the special case of terminological ontologies.

Overall, we may conclude from the pilot study that in a controlled experimental laboratory setting (the Lab) where participants conducted a sequence of three simple exercises within a very short time frame uncovering participants' specialized terminology render possible the subsequent drafting of terminological ontologies.

In particular, the pilot study shows that within a time frame of 15 minutes per exercise and given exercises of recalling expressions, describing meaning of those expressions and finally sorting structures, it is possible for participants to produce relevant domain-specific terminology which may further the subsequent drafting of a terminological ontology.

In addition, we may conclude that effective dual-mode visualizations of terminological ontologies in the textual or graphical formats are possible and may serve as a semantic and searchable component of a data catalogue. In this way, a data catalogue may enable end users in the following expansion and quality assurance of the terminological content ensuring both depth and breadth of terminological ontologies. This also means that effective dual-mode visualizations of terminological ontologies combining the textual and graphical formats may further enable end users of the data catalogue to query and search for data, terminology or knowledge needed in data-driven pursuits.

Finally, we may conclude that the user-centred approach may cover a variety of dimensions which contributes to the sustainability of digitalization efforts with a lasting impact by bridging gaps between data consumers and producers, as well as provide end users access to data information and communities

References

Chongtay, R., Last, M., Verbeke, M., & Berendt, B. (2013). Summarize to learn: summarization and visualization of text for ubiquitous learning. In *Proceedings of the 3rd IEEE Workshop on Interactive Visual Text Analytics at VIS 2013, The 3rd IEEE Workshop on Interactive Visual Text Analytics, Atlanta, GA* (pp. 1–4).

Bork, D., David, I., España, S., Guizzardi, G., Proper, H. A., & Reinhartz-Berger, I. (2024). The role of modeling in the analysis and design of sustainable systems: A Panel Report. *Communications of the Association for Information Systems* (CAIS). https://www.researchgate.net/publication/379035620_The_Role_of_Modeling_in_the_Analysis_and_Design_of_Sustainable_Systems_A_Panel_Report

Bowker, L. (2022). Multidimensionality. In P. Faber & M.-C. L'Homme (Eds.), *Theoretical Perspectives on Terminology: Explaining terms, concepts and specialized knowledge* (Chapter 6). John Benjamins Publishing. https://benjamins.com/catalog/tlrp.23.06bow

Cabré, M. T. (1999). *Terminology: Theory, Methods, and Applications.* John Benjamins Publishing. https://benjamins.com/catalog/tlrp.1

Cabré, M. T. (2003). Theories of terminology: Their description, prescription and explanation. *Terminology*, 9(2), 163-199. https://doi.org/10.1075/term.9.2.03cab

Christensen, L. L. W., & Madsen, B. N. (2023). Terminology as a Strategic Support Tool in Crisis Situations such as the COVID-19 Pandemic. *Terminology science and research - Journal of the International Institute of Terminology Research*, 26, 1–23. https://journal-eaft-aet.net/index.php/tsr/article/view/3467

De Nicola, A., & Missikoff, M. (2016). A Lightweight Methodology for Rapid Ontology Engineering. *Commununications of the ACM*. 59, 79–86. https://doi.org/10.1145/2818359

Ehrlinger, L., Schrott, J., Melichar, M., Kirchmayr, N., & Wöß, W. (2021). Data catalogs: a systematic literature review and guidelines to implementation. In *Database and Expert Systems Applications-DEXA 2021 Workshops*: BIOKDD, IWCFS, MLKgraphs, AI-CARES, ProTime, AISys 2021, Virtual Event, September 27–30, 2021, Proceedings 32 (pp. 148–158). Springer International Publishing. https://link.springer.com/chapter/10.1007/978-3-030-87101-7_15

Esposito, A., Calvano, M., Curci, A., Desolda, G., Lanzilotti, R., Lorusso, C., & Piccinno, A. (2023, May). End-User Development for Artificial Intelligence: A Systematic Literature Review. In *International Symposium on End User Development*, 19–34. Cham: Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-34433-6_2

Gruber, T. R. (1993). A translation approach to portable ontology specifications. *Knowledge acquisition*, 5(2), 199-220. https://doi.org/10.1006/knac.1993.1008

ISO/IEC 11179-4:2004 Information technology Metadata registries (MDR) Part 4: Formulation of data definitions.

ISO (2019). Terminology Work - Vocabulary. Part 1: Theory and application (1087-1). Geneva.

ISO (2022). Terminology work - Principles and methods (704). Geneva.

Hjorland, B. & Gnoli, C. (2022). *ISKO Encyclopedia of Knowledge Organization*. https://www.isko.org/cyclo/terminology

Kremser, W., & Brunauer, R. (2019). Do we have a Data Culture?. In *Data Science–Analytics and Applications*: Proceedings of the 2nd International Data Science Conference–iDSC2019 (pp. 83-87). Springer Fachmedien Wiesbaden. https://link.springer.com/chapter/10.1007/978-3-658-27495-5_11

Madsen, B. N., & Thomsen, H. E. (2009). Terminological concept modelling and conceptual data modelling. *International Journal of Metadata, Semantics and Ontologies*, 4(4), 239–249. https://www.inderscienceonline.com/doi/abs/10.1504/IJMSO.2009.029228

Madsen, B. N., Thomsen, H. E., Halskov, J. & Lassen, T. (2010). Automatic Ontology Construction for a National Term Bank. In *Terminology and Knowledge Engineering Conference* 2010, pp. 502–533. https://research-api.cbs.dk/ws/portalfiles/portal/58916334/TKE_2010_HET_BNM_JH_TL.pdf

Munappy, A. R., Bosch, J. & Olsson, H. H. (2020). Data pipeline management in practice: Challenges and opportunities. In *Product-Focused Software Process Improvement:* 21st International Conference, PROFES 2020, Turin, Italy, November 25–27, 2020, Proceedings 21 (pp. 168–184). Springer International Publishing. https://link.springer.com/chapter/10.1007/978-3-030-64148-1_11

Nielsen, L. P. (2015). *Knowledge Dissemination Based on Terminological Ontologies: Using Eye Tracking to Further User Interface Design.* Copenhagen Business School [Phd]. https://research.cbs.dk/en/publications/knowledge-dissemination-based-on-terminological-ontologies-using-

Nielsen, L. P. (2016). Target Users' Diagrammatic Reasoning of Domain-Specific Terminology. *TERM BASES AND LINGUISTIC LINKED OPEN DATA*, 224. https://research.cbs.dk/da/publications/target-users-diagrammatic-reasoning-of-domain-specific-terminolog

Nilsson, H. (2023): *Begrepp om begrepp*. Article published on The Swedish Association for Terminology (Terminologifrämjandet in Swedish). https://terminologiframjandet.se/h552a9FtZ/2023/10/27/begrepp-om-begrepp/

Sanctorum, A., Riggio, J., Maushagen, J., Sepehri, S., Arnesdotter, E., Delagrange, M., De Kock, J., Vanhaecke, T., Debruyne, C., & De Troyer, O. (2022). End-user engineering of ontology-based knowledge bases. *Behaviour & Information Technology*, 41(9), 1811–1829. https://researchportal.vub.be/en/publications/end-user-engineering-of-ontology-based-knowledge-bases

Seiner, R. S. (2014). *Non-Invasive Data Governance: The Path of Least Resistance and Greatest Success*. Technics Publications