Representing Traditional Knowledge through Ontology

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ABSTRACT

Traditional knowledge (TK) has a longstanding history of oral transmission from generation to generation, in which knowledge holders play a crucial role of custodianship. The relatively recent digitalisation of TK has given a new model of TK transmission, whereby TK is shared and searched online. A consensual representation of these processes that respect the needs of knowledge holders and indigenous information sharing protocols is desirable for the appropriate management of TK. On the one hand, this research is concerned with developing an ontology that efficiently represents digital forms of TK, and on the other hand with exploring an effective method for ontology engineering in this domain. An adaptation of the eXtreme design methodology was carried out for this purpose, in close collaboration with knowledge holders considered as domain experts. The resulting TK ontology is composed of 9 classes of which 2 subclasses, 7 object properties and 6 data properties. A byproduct is the identification of two content ontology design patterns that can easily be reused. The TK ontology was evaluated in three ways that are complementary to each other, through manual SPARQL query matching, interviews with domain experts and with an ontology expert. The greatest strengths of the ontology and method are concluded to be their simplicity and high reusability.

KEYWORDS

traditional knowledge, ontology engineering, ontology design patterns, modular ontology design

1 INTRODUCTION

Traditional knowledge (TK), also known as indigenous knowledge, is a broad range of knowledge that is rooted in indigenous ways of living and relating to the environment. Often intangible, it is a dynamic part of a community's culture and manifests itself through language but also traditions like ceremonies, rituals, songs, dances, healing processes or yet community management and rules [1]. It is often transmitted orally from generation to generation by knowledge holders who carry the role of custodianship. Knowledge holders worldwide have, however, expressed concerns over the loss of TK, and the need to capture knowledge in a format that is accessible to future generations [2]. TK has hence progressively been digitalised and shared online in audiovisual formats, which capture oral stories or songs in their original languages, but also visual practices like techniques, ceremonies or dances [2].

The appropriate management of such digital representations of TK is essential for its preservation and perpetuation. Knowledge management is the process of representing specific domains of knowledge to make it possible to search, navigate and compare information and thereby create value. Key tools in the management of TK are community platforms that allow for knowledge holders to classify, organise and disseminate TK according to their own needs. Developed by Washington State University, Mukurtu[1] is a content management system (CMS) that has enabled indigenous communities in Australia and North America to set up their own knowledge management platforms. A more recent initiative is that of Tribal Wisdom[2], a platform focused on connecting knowledge holders worldwide that aims to reveal relevant connections of knowledge items across themes and cultures.

Conceptual models serve as a blueprint to such information systems and their quality plays a central role in the success of the end system. Some recent attempts have been made at developing conceptual models of traditional knowledge in the form of ontology building [3],[4]. Ontologies are useful forms of knowledge representations for knowledge management purposes, that can be defined as a set of formal and explicit specifications of a shared conceptualisation [5]. Such a formalisation of the TK domain is useful for more effectively managing TK on community platforms.

The focus of this paper is thus to develop a conceptual model of TK, and more specifically a formal representation of that model in the form of an ontology. An ontology engineering method that is applicable to the TK domain is thereby expected to crystallise. The resulting ontology can be used for representing instances of TK, and as a basis knowledge representation for TK community platforms. It hereby aims to contribute to the field of knowledge engineering in the TK domain, and more generally to contribute to the preservation and perpetuation of TK. The research questions tackled are:

- RQ1: What is an ontology that can be efficiently used to represent digital forms of TK?
- RQ2: What is an effective method for ontology engineering in the TK domain?

[1] https://mukurtu.org/

[2] https://www.tribal-wisdom.org/

In the scope of this research, the efficiency of the ontology is evaluated by its functionality, or the degree to which it optimally represents items in the TK domain. This is measured by an ontology expert against 6 quality attributes i.e. completeness, relevance to requirements, practicability, expressiveness, reusability and reliability. The effectiveness of the ontology engineering method is moreover judged through the accuracy of the resulting model, or the degree to which it matches reality, as evaluated by domain experts with different cultural backgrounds.

2 RELATED WORK

2.1 Traditional knowledge management

The endeavour of TK management and preservation is tightly linked to advancements in Library and Information Sciences (LIS), a field concerned with knowledge classification, organisation and dissemination. A study by researchers at the University of Western Ontario with First Nations communities about the readiness of LIS to accommodate TK has revealed that TK has several qualities which distinguish it from other types of knowledge that are important to consider when designing management systems for it [2]. Firstly, TK is tightly embedded in local contexts, meaning that it cannot be separated from its local environment and history, and contextual information is a requirement to appropriately utilise the knowledge. Another key distinction is that TK often has an assigned custodian known as a knowledge holder who plays a pivotal role in protecting and transmitting the knowledge and its intended purpose. Finally, indigenous communities have specific protocols when it comes to sharing TK that are critical to take into account.

TK has a history of being exploited and extracted from its community of origin, a pattern that finds its roots in colonial practices [6]. Instead, community members should have control over how to share and circulate their knowledge. So, particularly for TK management systems, designers carry a responsibility to make decisions at the benefit of the end-user, the knowledge holder. While some information may be secret or sacred, others may be restricted to gender or specific community roles [6]. The local contexts project is an initiative by Washington State University that responds to this need for information governance, by developing a set of TK labels to identify information sharing protocols [6]. Inspired by the fair trade certification process of supermarket products, TK labels indicate the terms of use of TK and their intended users. The Mukurtu CMS makes use of these labels to create roles and determine access to content. It is such structural changes and design decisions that are critical to consider when managing TK.

2.2 Traditional knowledge ontologies

TK constitutes a rich body of tacit knowledge that is hard to express formally and is therefore mostly unavailable in codified form. A clear and explicit representation of TK in the form of an ontology is however fundamental for its management, preservation and evolution. Ontologies play an integral part in functions such as intent recognition, search and recommendation systems, automatic tagging and text mining. It would additionally enable the connection of distinct traditional knowledge systems so that indigenous communities can learn from each other. Moreover, making information sharing protocols more explicit would allow information systems to truly integrate indigenous standards for information control and governance.

Some attempts have been made at formalising the intangible cultural heritage (ICH) of indigenous communities, which can be considered a subdomain of TK. Ontology engineers at Wuhan University have for instance built an ontology for ICH in China together with domain experts to represent the inheritance process of such knowledge [3]. Key concepts and relationships of this model were ICH items, inheritors, categories and levels, and mainly expressed how ICH items can be classified. Another example is the ontology built by researchers at Bandung University that represents indigenous medicine knowledge in Indonesia [4]. With a focus on diseases, local medicine, tribes and origin mapping, the result is a conceptual model derived from patterns in indigenous medicinal practices. Both of these models make use of the CIDOC Conceptual Reference Model (CIDOC-CRM), which is considered a core ontology in the cultural heritage domain and has deliberately been developed to create interoperable data [7].

CIDOC-CRM is one of the many ontologies available on the web, some of which include thousands of concepts. These are typically large ontologies that are problematic for reuse as they are difficult to have an overview of, and it is difficult to anticipate the effects of their modification or extension [8].With ontology reuse being a key step in ontology engineering, new and more efficient methods for reuse have emerged. One trend in this direction is the use and development of Ontology Design Patterns (ODPs). ODPs are essentially a template of best practices or a set of concepts that is valid across different contexts and therefore reusable [9]. There are different types of ODPs, most of them catalogued in the online ODP Repository[3]. Content ODPs in particular encode conceptual patterns as opposed to logical or structural ones [10]. Tools to facilitate ODP reuse are moreover emerging, such as the brand-new Protégé plugin CoModIDE[4], which offers a simple functionality to drag and drop existing patterns in a visual user interface.

2.3 Knowledge engineering methods

There is a generally agreed upon set of steps in ontology engineering that includes stages of specification, conceptualisation, formalisation, integration, implementation and maintenance [11]. However, methods like the one described in Ontology 101 or the well known Methontology do not specify how to facilitate the reuse of ontologies or ODPs, whether it's the reuse of existing ones or the design of ontologies for future reuse [11], [12]. This is however an important step, especially when the aim is to build an ontology in a domain that is new to

[3] http://ontologydesignpatterns.org/wiki/Main_Page

[4] https://comodide.com/

formalisation processes. An adequate method would be one that yields a modular ontology that is flexible to different applications in the TK domain.

Early research in the development of ODPs has identified five ways they can be reused in the ontology design process [10]. First they can be imported in an OWL format and used as a building block directly in the new ontology. They can further be specialised, by creating subclasses and sub-properties in order to create a new version of the ODP. When extracting an ODP from an existing ontology, the classes and properties can be generalised in order to make the pattern easier to reuse in other contexts. ODPS can moreover be combined together in order to form an ontology that is composed of several modules. Finally, ODPs can be expanded, by extending their logical commitments, to cover the requirements of the new ontology.

eXtreme design is a methodology that focuses on modular ontology design and integrates all five operations in the ontology development process [8]. Unlike waterfall methodologies like Methontology, eXtreme design proposes an agile and iterative approach to facilitate modular ontology engineering. Its core principle is that it focuses on the customer of the ontology, or the agent that will make use of the ontology, who is not necessarily the end-user. Resulting ontologies are moreover task-focused so that every design decision is based on whether an extension fulfils a requirement and none is obsolete. It is moreover an iterative approach that allows engineers to incrementally build the ontology and constantly evaluate the reuse of ODP blocks. By integrating ODPs piece by piece, eXtreme methodology is useful for modular ontology engineering.

3 METHOD

The goal of this section is to specify the steps of the methodology used in the development of the TK ontology, explaining the intention and scope of the ontology, the modularisation process and specialisation of the corresponding ODPs. By doing so the ontology is meant to be reproducible and easier to reuse in future applications.

3.1 Methodology

The TK ontology uses an adaptation of the eXtreme design methodology because it focuses on modular design and provides an accurate description of how to reuse content ODPs [8]. Originally, the eXtreme design methodology is composed of an ontology modularisation phase and an ontology integration phase. For the scope of building a conceptual model, only the conceptualisation including the requirements elicitation based on research into the intention and scope, module creation, ODP specialisation, and ontology testing were carried out as seen in figure 1. In addition, it is recommended by the designers of this methodology to carry out the modularisation in design pairs, so that each module is the product of collaboration, and each pair focusses on one module. This was, however, not within the capacity of this study, and therefore the modularisation is carried out solely by the author. The ontology is built using the open source software Protégé[5] developed by Stanford University, as it is a widely recognised ontology editor with clear documentation that makes it accessible to non-expert users.

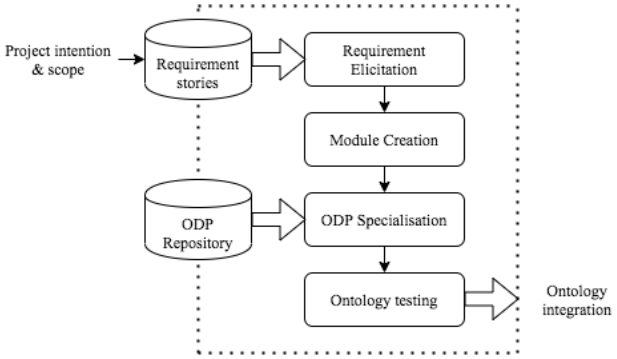

Figure 1: Adaptation of the XD workflow that shows the design phases of the TK ontology

3.2 Intention & Scope

The purpose of the TK ontology was to form a consensual representation of the TK domain that knowledge holders from different cultural backgrounds commend. It should more specifically represent TK items and the contextual information necessary for their transmission between different indigenous communities. As TK is increasingly digitalised in the form of text, image, audio or video files, a model of how these should be circulated according to indigenous information sharing protocols is desirable. The level of granularity is directly related to the competency questions and terms identified, but is expected to be high level as it covers a general overview of the domain. The intention is to design the ontology in a modular way so that it is reusable and can be specified to different contexts of TK management. More importantly, it should comply with the needs of knowledge holders who are the righteous custodians of TK.

In the eXtreme design methodology, users of the ontology are also called customers, and can be distinguished in two types, namely those who use the ontology directly or indirectly [8]. In this case, the intended customers who make direct use of the ontology are knowledge engineers who build community owned platforms for TK management purposes, like Tribal Wisdom or the projects that emerge from the Mukurtu CMS. The indirect users are intended to be community members involved in the transmission of TK, and more specifically knowledge holders. When using the system, knowledge holders can have the role of a knowledge seeker in which they exhibit knowledge seeking behaviour like looking up or exploring knowledge items, or the role of a knowledge sharer wherein they exhibit knowledge sharing behaviour like publishing or controlling knowledge items.

Individual interviews and card-sorting activities were held with knowledge holders in order to better understand these sharing and searching processes. Interviewing is a knowledge

[5] https://protege.stanford.edu/

Table 1: A selection of constructed examples of sub-stories and their equivalent instance-free phrases

Substories	Instance-Free Phrases
"How to perform Yoni Steaming" is a video about vaginal steaming that has been created by Anna in 2019.	An item is a type of media about a topic that is created by a knowledge holder at a period in time.
Anna is a member of the Sarayaku tribe, in Ecuador. Anna has created items about multiple fertility rituals.	A knowledge holder is a member of a community, which is located in a place. A knowledge holder creates items about multiple topics.
In the Sarayaku community, vaginal steaming is a women-restricted ritual that may only be passed on by women.	A community has a number of TK labels associated with an item.

elicitation technique that is proposed by multiple ontology building methods as a way to acquire knowledge from domain experts [13]. It allows to define the user's needs, and key concepts in their understanding of digital TK. Card-sorting on the other hand is a useful activity for the classification of entities, and to establish a taxonomy from a list of concepts and terms. Each activity was carried out with five different knowledge holders of the Tribal Wisdom community. Due to restrictions caused by the COVID-19 pandemic, interviews were held through an hour long online video calls and card-sorting through the Optimal Sort [6] remote testing function, which can be seen in Appendix B. All knowledge holders were experts of a type of traditional knowledge, from healing to wisdom teaching, and originate from different cultures, ranging from Finland to Curacao, Ecuador and the Netherlands. They all have extensive experience sharing and searching digital traditional knowledge, on platforms varying from social media to community libraries. The interviews were semi-structured, with questions on digital traditional knowledge items and how they are circulated as can be found in the appendix A. The insights from the interviews and card sorting activity were used to create user stories, assess needs and define key requirements for the ontology as detailed in the following section.

3.3 Module creation

A useful step in determining the functional requirements of an ontology is the creation of a user story [8]. Insights from the interviews were synthesised and used to generate a constructed scenario of how a TK item is shared and searched. Each step was divided into a substory as seen in Table 1, and was translated into instance-free phrases to reveal key concepts and their relationships. Patterns in concepts like knowledge items, knowledge holders or communities started to emerge as well as their definitions. The card sorting activity was then useful to determine a pre-glossary of terms for the key requirements of the ontology. All terms and lexicon used in the interviews were listed and participants were asked to categorise them. These findings were later used to determine how key concepts should be called.

The interviews with domain experts were moreover useful to gain insight into their needs and expectations when it comes to making use of traditional knowledge management platforms. The majority of the knowledge holders expressed the need to have governance over how traditional knowledge items are shared and with whom. This aligns with previous research on the importance of giving the knowledge holders the agency to manage how traditional knowledge circulates, as some elements of it may be sacred or exclusive to certain members of their communities [2]. Another need when it comes to learning about traditional knowledge from other communities was the need to connect with other knowledge holders about a specific topic. Finally, it is useful to compare traditional knowledge across themes and cultures, in order to learn about alternative interpretations. These three distinct needs are what determined the modules and their requirements.

3.4 ODP Specialisation

The three main needs expressed by knowledge holders were useful in guiding the selection process of the system's key requirements. Competency questions were formulated and selected to match these needs as can be seen in table 2. It is in fact expected that the answers to these competency questions provide the contextual information necessary to fulfil the user needs. The TK ontology is hence considered successful if it forms a solution that covers all requirements at hand.

A critical step in creating such a solution in the case of the eXtreme design methodology, is the reuse of existing ODPs. These are intended to guide non-expert engineers by forming functional building blocks that can be imported in OWL formats and specialised. Most content ODPs are annotated with a set of competency questions that were manually analysed and matched with the competency questions relevant to this ontology. In this process, all content ODPs from the online ODP repository were taken into consideration. It was, however, concluded that none of the content ODPs were relevant for the TK ontology as their competency questions were not compatible. There were in fact no content patterns in the domain of TK or pertaining to the transmission of knowledge items. The manual process of matching key requirements was moreover laborious and inefficient.

More efficient for this purpose was the Protégé plugin CoModIDE, which offers a selection of well-documented patterns that can be dragged and dropped in the modelling process, in order to facilitate modular ontology engineering. In this library, two patterns appeared to be relevant as building blocks for the TK ontology. The stub pattern is a minimal pattern that is applicable to many situations and allows to precise the nature of a concept, such as the name stub that allows to express the title of a knowledge item or the name of a knowledge holder. The provenance pattern on the other hands allows to express the origin of a concept, so for instance who created a knowledge item or to

[6] https://www.optimalworkshop.com/optimalsort/

Table 2: List of user needs and their corresponding competency questions and constructed examples

User Needs	Competency Questions	Constructed Examples
Knowledge holders want to compare TK items between different cultures.	CQ1. Where is a TK item practised? CQ2. How does a TK item from one community differ from another community? CQ3. What TK items originate from a Country?	e.g. 1 Where in the world do people practise Yoni steaming? e.g. 2 How is the Sun dance ritual in the Hopi tribe different from the Sun dance ritual by the Cree people? e.g. 3 What traditional knowledge is practised in Curacao?
Knowledge holders want to connect with other knowledge holders about specific topics.	CQ4. Who created a TK item? CQ5. What other TK items has the knowledge holder created?	e.g. 4 Who created the video "How to make homemade briquettes"? e.g. 5 What else does Anna know about?
Knowledge holders want to manage how TK items are shared.	CQ6. What is the information sharing protocol of a particular TK item? CQ7. Who are the members of a community?	e.g. 6 What are the rules regarding sharing information about Yoni steaming? e.g. 7 Who belongs to the Sarayaku tribe?

which a community a knowledge holder belongs. Whereas often ODPs are used as abstract templates to be specified to a domain, these CoModIDE building blocks could be reused as actual building blocks in the modelling process.

4 MODELLING RESULTS

4.1 Model description

The TK ontology focuses on the transmission of TK items between knowledge holders from different communities. Its aim is to facilitate the sharing and searching of TK items in digital formats, which can be text, image, video or audio files that represent a form of traditional knowledge. These representations are commonly created by knowledge holders in order to share their TK with members of their own communities, other communities, or the wider public. It is a high level conceptual model that gives an overview of the key concepts necessary to manage TK according to the knowledge holder's needs. The TK ontology is composed of 9 classes of which 2 subclasses, 7 object properties and 6 data properties that each have their inverse properties, as can be seen in the graphical representation in figure 2. It is moreover filled in with instances from the Tribal Wisdom platform to exemplify the use of the model. The TK ontology is available online in a version controlled repository[7], and the graphical representation can be interacted with using the WebVOWL online editor[8].

TK Item
Its main entity is the TK item class, which correspond which corresponds to any digital representation of a piece of knowledge, in the form of a text, image, video or audio file. An instance of a TK item could be an audio recording of a wisdom teaching, an image of a Sun Dance ritual or a textual description of a herbal medicine.

Knowledge Holder
The Knowledge Holder class represents any agent that has custodianship over a TK item. These agents can be either an individual person or a group of people, like an organisation or an institution that holds knowledge over a particular item. They play a key role in the transmission and management of TK. The properties of the class include the creation of TK items and the membership to a community.

Community
The community class represents any group of agents that identify to the same culture. It is essentially a group of knowledge holders that recognise themselves as originating from the same nation, tribe, or simply the same community. The main property of this class is hence also the membership of knowledge holders, which should in practise be verified, as this membership has repercussions on the knowledge holder's rights in terms of information sharing protocols. Instances of the class community could be the Sarayaku tribe, the Hopi nation or the Karelian people.

Geography
The geography class represents a physical location in space that can be identified by a country or city. This is an important piece of contextual information to the TK item as a key characteristic of traditional knowledge is that it is bound to a location. Instances of this class are countries like Ecuador or Finland.

[7] https://github.com/biktorrr/tkont

[8] http://www.visualdataweb.de/webvowl/#iri=https://raw.githubusercontent.com/biktorrr/tkont/master/TraditionalKnowledgeItem.owl

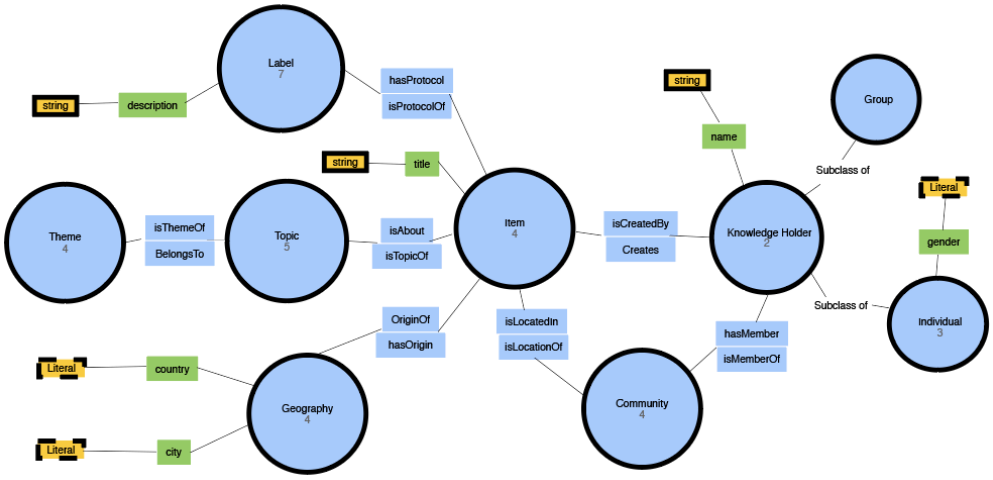

Figure 2: Graphical representation of the TK Ontology generated with the WebVOWL editor

Table 3: Description of the ODP TK Item Categorisation

Component	Description
Name	TK Item Categorisation
Intent	To model traditional knowledge items and how they are categorised, in order to be more easily searched for and compared with other knowledge items.
Domain	Traditional knowledge
Competency question	• What is the item about? • What theme does an item fall under? What other items are there within this theme? • What other items are there about this same topic?
Solution description	The pattern connects a knowledge item to a topic and the theme it falls under.
Reusable OWL building block	http://www.semanticweb.org/loishutubessy/ontologies/2020/6/ItemCategorisationODP
Consequences	It allows the designer to express what an item is about to facilitate searching and comparison with other items.
Scenarios	• "How to perform Yoni Steaming" is a video about vaginal steaming • Vaginal steaming is a type of alternative health treatment and a type of cleansing ritual • Another type of alternative health treatment is charcoal cleansing
Elements	• TK_Item (owl:Class) • TK_Theme (owl:Class) • TK_Topic (owl:Class) • Belongs_To (owl:ObjectProperty) • isAbout (owl:ObjectProperty) • isThemeOf (owl:ObjectProperty) • isTopicOf (owl:ObjectProperty)

Table 4: Description of the ODP TK Item Provenance

Component	Description
Name	TK Item Provenance
Intent	To model the cultural and geographical origin of a traditional knowledge item.
Domain	Traditional knowledge
Competency question	• Who created an item? • Where is an item practised? • What other items did a knowledge holder create?
Solution description	The pattern relates a traditional knowledge item to its creator in order to explain its provenance.
Reusable OWL building block	http://www.semanticweb.org/loishutubessy/ontologies/2020/6/ItemOriginODP
Consequences	This pattern allows to query the origin of an TK item, that is who created it and where it's from, in terms of cultural belonging and geographical location.
Scenarios	• Anna created the knowledge item "How to perform Yoni Steaming" • Anna is from the Sarayaku tribe
Elements	• Community (owl:Class) • Geography (owl:Class) • Item (owl:Class) Knowledge_Holder (owl:Class) • Creates (owl:ObjectProperty) • hasLocationOf (owl:ObjectProperty) • hasMember (owl:ObjectProperty) • hasOrigin (owl:ObjectProperty) • isCreatedBy (owl:ObjectProperty) • isLocatedIn (owl:ObjectProperty) • isMemberOf (owl:ObjectProperty • OriginOf (owl:ObjectProperty)

Label
The label class represents an information sharing protocol that describes how a TK item must be circulated. It is directly related to the TK item class, and has a description that explains its corresponding rules. Possible instances of this class are the TK Sacred/Secret label which indicates a particular item is highly protected or the TK Women Restricted label which indicates the item is restricted to certain members of a community. These labels are directly derived from the TK labelling practises derived from the WSU Local Context's initiative [6].

Topic
The topic class represents the subject matter of a concept, or that which a TK item is about. It is useful for categorising items and is directly related to the TK item class through the relation 'is about'. Instances of topics are keywords like cotton weaving, traditional healing or boat building.

Theme
The theme class represents a unifying idea behind a group of concepts, in this case behind a group of topics. It is another class that is useful for the categorisation of items as it allows to group them under broader concepts. Instances of themes are concepts like Food & Cooking or Shelter & Buildings

4.2 ODP Proposal

In the development of the TK ontology, it became apparent that there are two distinct modules that each fulfil a different set of requirements within those outlined in the overall ontology. On the one hand, the relationships between knowledge items, themes and topics seemed to cover competency questions regarding the categories to which TK items belong. On the other hand, the relationships between knowledge items, knowledge holders, communities and geographies seemed to cover competency questions regarding the provenance of a TK item.

Under the definition of an ODP being a subset of an ontology that can be reused independently as a building block in other ontologies, these modules are proposed to be used as content ODPs. The two distinct ODPs derived from the TK ontology are outlined according to the description framework used in the online ODP repository, as can be seen in table 3 and table 4. By describing their elements and the corresponding competency questions, the aim was to prepare the ODPs for submission to the ODP online repository, and to be used as patterns in the CoModIDE library.

5 EVALUATION

The TK ontology was evaluated in three different ways that are complementary to each other and provide a thorough overview of its potential use and limitations. A model is an approximate conceptualisation of reality, and it is through evaluation that the distance between the real world and the model is measured. A key measure is the comparison of the ontology with the specification requirements. This was firstly done by manually translating the competency questions into SPARQL queries, and controlling whether the ontology provides the corresponding results. This gives insight into the basic functionality of the ontology. Ontology validation is the process by which the meaning of the definition is matched against the conceptualisation the ontology is meant to specify. This was carried out with some of the same domain experts that were initially involved in the knowledge acquisition phase. Ontology verification on the other hand is the process by which the ontology is evaluated against specified quality criteria, which was carried out in direct accordance with an ontology expert. These three evaluation methods are detailed in the following sections.

5.1 Functional evaluation

In order to evaluate the model against the system requirements, the competency questions were translated into SPARQL queries. By doing so, it is verified whether the TK ontology provides results for the competency questions, and thereby fulfils the user's needs. As can be seen in table 5, it was possible to translate all competency questions into SPARQL queries, as they are simple questions that yield unambiguous statements. A more elaborate query is the one corresponding to CQ2 which allows to compare two knowledge items based on their geographical locations. It is such uses of the TK ontology that would eventually make TK management platforms more useful to knowledge holders.

5.2 Domain expert evaluation

Due to limited availability, the TK ontology validation was carried out with two of the five domain experts that were involved in the knowledge acquisition phase of the modelling process. Knowledge holders were asked to compare the model against their expert knowledge. Through online individual video calls of 30 minutes, they were presented with a graphical representation of the TK ontology generated with the WebVOWL editor, that they could interactively explore. They were asked to perform a think-aloud protocol, with a focus on the definitions of the classes and properties.

Both knowledge holders expressed that the model seemed complete, as all key elements required for the transmission of traditional knowledge were covered, and the terminology of classes like 'knowledge holder' and 'item' are familiar terms in the TK domain. One of the knowledge holders mentioned that the Geography class was, however, too broad. A city or a country should be replaced by a region as it is possible that communities identify to a region that stretches over multiple countries. Karelia, for instance, is a region that is divided among northwestern Russian Federation and Finland, that the Karelian people identify as their land. It was also expected by both knowledge holders that most TK items have strict information sharing protocols as TK items are predominantly exchanged among knowledge holders from specific communities as opposed to with the wider public. This means that the membership relation between the Knowledge Holder class and the Community class is critical, and might require more specific values to implement the protocols such as the knowledge holder's gender or status in their community.

Table 5: Competency questions of the TK ontology and their matching SPARQL queries

User Needs	Competency Questions
CQ1. Where is a TK item practised?	SELECT ?Geography WHERE {?Geography OriginOf <Item1> }
CQ2. How does a TK item from one community differ from another community?	SELECT ?item1attr ?item2attr WHERE {?KnowledgeHolder1 Creates <item1>. <item1> isAbout ?topic. ?KnowledgeHolder1 isMemberOf ?Community1. ?KnowledgeHolder2 Creates <item2>. <item2> isAbout ?topic. KnowledgeHolder2 isMemberOf ?Community2. <item1> ?property ?item1attr. <item2> ?property ?item2attr. FILTER (?Community1 != ?Community2) FILTER (?KnowledgeHolder1 != ?KnowledgeHolder2) }
CQ3. What TK items originate from a Country?	SELECT ?Item WHERE {?Item hasOrigin <Geography1>
CQ4. Who created a TK item?	SELECT ?KnowledgeHolder WHERE {?KnowledgeHolder Creates <Item1> }
CQ5. What other TK items has the knowledge holder created?	SELECT ?Item WHERE {<KnowledgeHolder1> Creates ?Item }
CQ6. What is the information sharing protocol of a particular TK item?	SELECT ?Label WHERE {<Item1> hasProtocol ?Label }
CQ7. Who are the members of a community?	SELECT ?KnowledgeHolder WHERE {?KnowledgeHolder isMemberOf <Community1> }

5.3 Ontology expert evaluation

The verification of the TK ontology was done with an ontology expert in the field of digital humanities and cultural heritage. This took the form of a 30 minute long interview, for which the ontology expert was given time to inspect the model beforehand. Expert verification is useful to gain technical insight into the quality of the conceptual model. For this purpose, a qualitative evaluation method was chosen, in which the expert was asked to evaluate six quality attributes of the model, i.e. completeness, relevance to requirements, practicability, expressiveness, reusability and reliability [14]. A WebVOWL interactive graphical representation of the TK ontology was shared with the expert, who responded to each attribute through video call.

Completeness

This attribute is based on the coverage of the user requirements [14]. According to the key requirements, the model had to be a generic representation of TK transmission. It is considered a simple model that effectively covers its purpose. By remaining generic, it is applicable to any type of traditional knowledge. According to the expert, all key concepts of this domain are covered. When combined, they allow for a range of queries that are not stated in the requirements, like listing which topics are recurrent in specific geographies. With regards to its usage in culturally diverse contexts, it is however not ready for multilingual use. Since classes and properties do not have placeholders, the model doesn't support multilingual coupling.

Reusability

This attribute verifies on the one hand whether the model employs previously developed models, and on the other hand whether it can be reused in the future [14]. The expert found it noteworthy that the model does not reuse existing models, whereas the Knowledge Holder class can be represented as FOAF agent concepts, and the Topic and Theme classes can be represented as SKOS concepts. The model is, however, designed to be effectively reused in future modelling processes as it is simple and the terminology is accessible. Thereby the proposal of the categorisation and provenance patterns facilitate future reuse.

Relevance to requirements
This attribute refers to whether the concepts of the model are relevant to the ones required by the user [14]. The minimality of the model is evaluated as a strength as it strictly focuses on fulfilling the user needs. Three concerns were however raised regarding its representation. Firstly, the classes of Topic and Theme seem redundant as they both specify the meaning of the knowledge item. Then there seems to be a missing link between the class Item and Community to express to which community a knowledge item belongs, as it is only indirectly related to this class through the concepts of Knowledge Holder and Geography. Finally, the distinction between the Group class and Community class is unclear.

Practicability
This attribute measures whether the concepts and elements of the model can be materialised [14]. As all the concepts were formally expressed in an OWL format, the model was considered practicable and flexible enough for implementation.

Reliability
This attribute measures whether the system is prone to failure, which is difficult to measure in a graphical representation of the model as it would have to be tested [14].

Expressiveness
This attribute measures whether the model is expressive in a natural way that requires no further explanation [14]. The expert verified that the TK ontology can express all competency questions and answers. The main limitations are the missing relations mentioned in the relevance to requirements.

6 DISCUSSION

Limitations of the TK ontology can mainly be traced to the modelling and evaluation phases of the methodology. In both phases, domain experts were critical for the outcome, however their availability was inconsistent due to the context of the COVID-19 crisis. A consistent amount and larger pool of knowledge holders could in the future yield a richer evaluation. The steps followed in the design of the TK ontology are moreover an adaptation of the eXtreme design methodology, with a focus on the ontology modularisation phase [8]. The research can be extended by also performing the subsequent ontology integration phase. It could moreover be improved by performing the modularisation phase itself in design pairs, as recommended by the designers of the original methodology [8]. Based on the current evaluation it is difficult to conclude how far the TK ontology is useful for the whole TK domain. This would have to be tested with a wider variety of instances. This could moreover be measured through the reuse of the two content ODPs in future ontology engineering projects in the TK domain. Another future direction would be to extend the current TK ontology by linking it to wider existing ontologies.

7 CONCLUSION

The focus of the research was to build a conceptual model of TK that can serve as basis knowledge representation in the development of TK management platforms. On the one hand, it was concerned with delivering an ontology that can be efficiently used to represent digital forms of TK, as formulated in RQ1. The resulting TK ontology is a simple representation of 7 high level concepts in the domain, and their relationships. A byproduct is the identification of two content ODPs, namely the Item Categorisation pattern and the Item Provenance pattern. The model is concluded to be functional as it covers all key requirements set by the knowledge holders in the intention and scope of the project, as evaluated through a manual SPARQL query matching process. It is moreover evaluated by an ontology expert on 6 quality attributes, and is considered to be complete and relevant to requirements, and especially highly reusable for future research. The ODPs are described according to the ODP repository framework with the intention of being submitted, and used in tools like CoModIDE.

On the other hand, the research was concerned with exploring an effective method for ontology engineering in the TK domain, as formulated in RQ2. All steps of the adaptation of the eXtreme design methodology were thoroughly followed, including requirement elicitation, module creation, ODP specialisation and ontology testing. Particularly the requirement elicitation was intensively carried out through two interviews as well as card-sorting activities, followed by user story and instantiation exercises that allowed to formulate clear user needs and system requirements. Each of these steps is described in detail which makes the method highly reproducible. Domain experts with different cultural backgrounds intuitively understood the structure of the resulting ontology and considered all key concepts of the TK sharing and searching processes to be represented. Given the research's goal to generate a general model that covers the TK domain, it can be said that it is accurate. The method is effective in designing an ontology that corresponds to the end user's needs, and yields a modular ontology that is prone to reuse.

Overall the ontology is simple and general, which makes it adaptable to many applications in the TK domain. The results of the research are publicly accessible and designed for elaboration, and can be used by knowledge engineers of TK management platforms. Thereby the aim to contribute to the improvements of TK preservation and perpetuation is considered achieved.

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8 APPENDIX

A INTERVIEW QUESTIONS

The interview was semi-structured and guided by the following questions:

- What are examples of TK stories you have shared?
- Describe/draw a well structured knowledge story.
- Tell me more about the form and content of the story.
- Tell me more about what is important to know about the story.
- What are examples of channels you use to share your stories?
- Describe/draw the online story sharing process.
- When do you decide it's necessary to share a story?
- What's the desired outcome of sharing a story?
- Who is the target audience of your story?
- What contextual information is necessary about the story?
- Describe/draw the ideal online story sharing process.

B CARD-SORTING RESULTS

The results of the card-sorting activity, including an overview and an analysis, can be inspected on Optimal Sort through the following link: https://tinyurl.com/y3d5wym4