A Framework for Using Questions as Meta-tags to Enhance Knowledge Support Services as Part of a Living Lab Environment

Albertus A. K. Buitendag, Fredrik G. Hattingh, and Jacobus S. van der Walt
Tshwane University of Technology
Pretoria, Tshwane, South Africa

buitendagAAK@tut.ac.za hattinghFG@tut.ac.za
vanderwaltJS@tut.ac.za

Abstract

The power and importance of collaboration and knowledge sharing within knowledge-intensive innovation focused environments is a huge driving force in today's knowledge driven economy. Decisions taken are based on knowledge available, and knowledge is gained by asking questions. Within a Living Lab environment, information and knowledge dissemination can take on many forms and are cardinal to the Living Lab's successful operation, where the creation of innovative solutions is a key deliverable. This paper presents a framework that incorporates questions as additional metadata tags to catalyze knowledge discovery. The question metadata are used as part of a collection of knowledge support services developed utilizing a Living Lab approach. The objective of the knowledge support services is to provide mechanisms to enable and fulfill various knowledge oriented activities such as information acquisition, learning, and knowledge sharing. Each of the knowledge oriented activities is enabled by the implementation and use of Knowledge Objects. This paper reviews popular metadata formats, including the Dublin Core standard, the Learning Object Metadata standard, and the Sharable Content Reference Model (SCORM). Also presented is the concept of a Knowledge Object Wrapper, a collection of metadata as part of a class hierarchy, which includes questions. The concept of a Knowledge Object is also revisited.

Keywords: Knowledge Objects, Knowledge Object Wrapper, Knowledge sharing, Knowledge-support, Learning Objects, Living Labs.

Introduction, Background, and Prior Research

This paper continues and expands on research which was presented in 2009 and 2012, in which van der Walt, Buitendag, Jansen Van Vuuren, and Zaaiman (2009) modeled a Living Lab (LL) around a factory concept. Buitendag, van der Walt, Malebane, and de Jager (2012) subsequently expanded the framework to include broader descriptions and presented various operations as services, collectively described as *knowledge support* *services*, to be included as part of the Knowledge Factory.

The research is based on a LL designed for an agricultural Community of Practice (CoP) which is also applicable to any knowledge intensive and dependent domains, such as Higher Education, or research and innovation organizations in the public and private sectors. Within the agricultural sector, extension officers often fulfill the role of knowledge agents. Extension offices are key enablers in the provision of knowledge and alternative methods, to persuade clients such as emergent farmers to apply new or improved practices out of their own free will. This includes actions of facilitation within the principles of help to self-help and to prepare clients to better handle future problem situations. Some of the knowledge-operation related problems identified by Buitendag and van der Walt (2011b, p. 70-72) include the following:

- Difficulty in accessing information.
- Lack of access to timeous knowledge.
- Duplication of knowledge resources.
- Inadequacy in interpreting current knowledge sources.
- Poor communication and dissemination of information and knowledge.

Demby (2012, p. 8) exclaimed that one of the biggest problems Africa faces with regard to agricultural extension is the fact that so little emphasis is placed on establishing and maintaining sound knowledge management tools and practices.

Amour (2011) highlighted a common problem experienced by many farmers seeking extension services, by stating that “appropriate advice must be offered to farmers efficiently and regularly - Advice is like salt – only give it when asked for!”

From the problems listed it is evident that access to the correct and satisfactory knowledge relating to the questions posed is of cardinal importance for the successful functioning of agricultural extension services.

The predominant research question this article aims to address is as follows:

How can current Knowledge Object metadata models be enhanced to aid effective knowledge discovery in problem solving environments such as Living Labs?

In this paper we also aim to provide new insights, thoughts, and perspectives on the utilization of Learning Objects (LO), based on the LO Metadata standard. We revisit the concept of the Sharable Content Object (SCO) as part of the Sharable Content Reference Model (SCORM), and the classic Dublin Core (DC) metadata standard, based on a literature review. The authors provide their own interpretation of the concept of a Knowledge Object (KO) and highlight how the various activities of a LL may be supported by the implementation of KOs, based on the researchers’ definition. We also provide a more detailed description of the functionality of the proposed Question and Answer service that utilize Knowledge Objects, based on questions. The subsequent description and framework proposed in the latter part of this paper are based on design and creation research principles.

Living Labs – An Overview and South African Perspective

Cunningham, Herselman, and Cunningham (2011) define a Living Lab as “systemic initiatives, which focus on creating multi-stakeholder collaboration in different stages of the research, development and innovation (RDI) process. The concept refers to a research and development methodology where innovation such as services, products and application enhancements are created and validated in collaborative, multi-contextual empirical real-world settings. In Living Labs, users or citizens are seen as a source of new innovation, as co-creation or application of ICTs or ICT-enabled services. Living Labs are platforms for exploring these opportunities in various areas.”

Living Labs encourage innovation practices as well as the exchange of new ideas and information, which promote the concepts of innovation and co-creation (Kusiak, 2007, p. 866). According to Herselman, Marais, and Pitse-Boshomane (2010) each of the current established LLs within the network in SA has distinctive uniqueness ***focusing*** on the capacity building of the communities involved, as well as the enhancement of the innovation skills of the individual community.

Within South Africa, the LL has become a popular platform to facilitate community engagement and collaboration. LLs within South Africa often aim at creating, innovative products and solutions to address the needs of the community (LLiSA, 2011).

Living Lab Factory Framework – A Review

Figure 1 depicts an adaption of the Living Lab (LL) factory framework presented by Buitendag, van der Walt, Malebane and de Jager (2012) based on the original work of van der Walt et al. (2009), where the LL is modeled around the creation and utilization of virtual factories. As part of this research we elaborate on the service factory and provide new insights in the functioning and composition thereof. The factory framework presented is in line with the definitions of Cunningham et al. (2011), Herselman, Marais and Pitse-Boshomane (2010), and Kusiak (2007, p. 866), where emphasis is placed on innovation and co-creation activities.

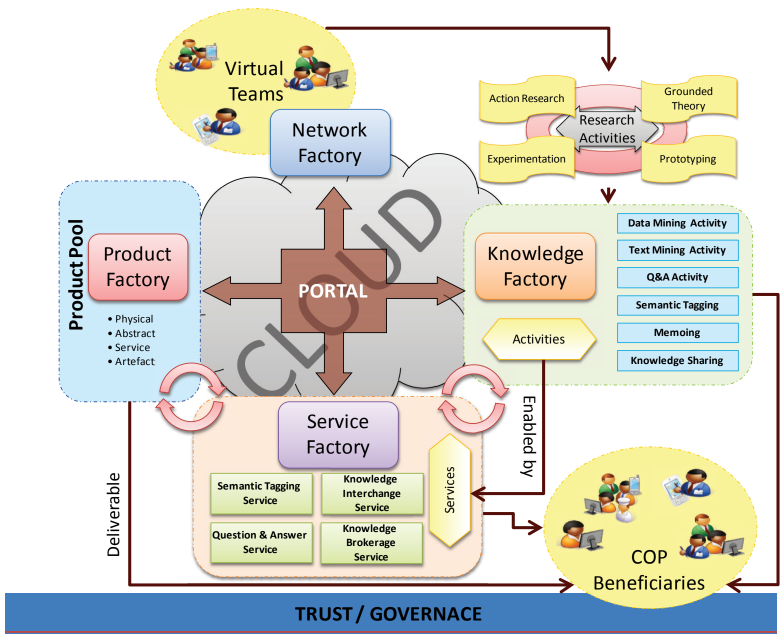

Figure 1 – Living Lab Factory Framework

Each of the virtual factories is modeled around the logical groupings of similar functions and activities. Every activity results in a deliverable which could be of both a physical or non-physical nature. The virtual factories are partially based on the concept of a real life factory with some similarities to the factory design pattern. The logical model of the factory design pattern is based on the idea that products are created in a factory in which a client focuses on its discrete role in the application, without concerning itself with the details of how the product is created (Purdy, 2002). With reference to the framework, the client could either be a human client such as a research officer or a software client requesting the invocation of other software services Buitendag, Hattingh and van der Walt (2012). The predominant purpose of the Network Factory (NF) is for the profiling and registration of community members.

The predominant purpose of Service Factory (SF) is to deliver and utilize current available services to help meet the objectives and functioning of the LL. Added as part of this research we present a collection of services for knowledge support as part of the SF. These services utilize the proposed knowledge object design incorporating questions as meta-tags.

The Knowledge Factory (KF) promotes, stimulates, and provides an environment for the generation and discovery of knowledge through the application of various research activities and methods.

The Product Factory (PF) can also be called the 'tools factory' since it allows for the creation of tools and methodologies in the LL.

To summarize, the Network Factory aims at establishing groups and virtual teams of people based on the social networking concept. The various virtual teams will often participate or initiate different research activities. The research activities conducted as part of the KF will sometimes result in the generation of new knowledge such as the identification of a new product or service that is required. In most cases the research activities will be driven by a question. The data, information and knowledge generated as part of the research process are classified and categorized for future use within the KF.

The KF uses standard tagging and metadata descriptions in the classification of all knowledge resources. Often new services will be designed based on the knowledge generated as part of the KF. The services are rendered and created to form part of the SF. The development and deployment processes of the service could initiate new research activities involving some or all of the virtual team members. Various activities of the KF are enabled through the utilization of services previously designed and developed in the SF. The SF and KF activities often result not only in the creation of services, but could also lead to the creation of artifacts.

The Product Factory as well as the SF utilizes knowledge objects (KOs). We regard KOs as artifacts enabling the transfer of knowledge which are based on questions. The proposed knowledge discovery and support services also aid in the classification of knowledge obtained through some of the LL activities. Some of the envisioned activities include research, experimentation, innovation, and artifact development. Through the research activities new knowledge is derived and processed as part of the Knowledge Factory. The created knowledge objects are categorized, stored, and made available for future referencing and use. The knowledge objects are also part of the LL domain which could be available for use by other LLs and communities. In some instances the knowledge objects could be sold to generate income (Buitendag. 2013; Buitendag, Hattingh, & van der Walt, 2012).

Service Factory & Knowledge Support Services

In order to provide a better clarity of the activities relating to the Knowledge Factory we need to provide our definition of knowledge support in a Living Lab (LL) environment. The researchers define knowledge support as *an activity-oriented, question based process aiding knowledge creation, facilitation, sharing, codification, and application for its intended user group.*

Without proper knowledge support services, neither the KF nor the PF would be able to function successfully. The SF provides the service infrastructure and resources; prospective innovators, infopreneurs, and entrepreneurs need to create innovative LL intended support products and tools. Buitendag, van der Walt, Malebane and de Jager (2012) listed the following SF services as a collection of knowledge support services for use as part of the SF, to drive the knowledge activities of the KF (cf. Figure 1):

1. A question and answer service (QAS) which allows users to post questions and obtain answers. The questions as well as the responses are semantically tagged to provide inference services for future questions posted, which will speed-up the knowledge acquisition processes.
2. A knowledge interchange (KI) service, which supports the sharing of information among people (online collaboration, i.e. question and answer postings) or through doing research e.g. grounded theory.
3. A knowledge brokerage (EKB) service using a reverse auction process.
4. A semantic tagging and classification service, which forms part of the semantic layer, to aid in the understanding of research notes, of both current and future knowledge related documents.

In each of the services, questions play an important role and are regarded as the driver and catalyst for the embedded and interrelated activities of which each service is composed. The NF aims at answering questions such as: *Who is the best candidate to address a certain issue? Which organization could be consulted for advice?* The KF is driven by research questions identified by the various LL stakeholders. Knowledge generated as part of the KF operations often requires the creation of services, such as an advisory service or, within the scope of this research, the collection of knowledge support services. The service factory is driven by questions such as: *Which existing APIs could be used to facilitate some of the required functionality? How should a new service be designed?* As products or artifacts are generated for use in the PF, questions such as the following, may come to light: *How efficient is the product? How can the product be improved?*

Knowledge & Learning in Living Lab Environments

Living Labs (LL) rely heavily on knowledge for new innovation and value chain optimization. Questions are the driving force in the discovery of new knowledge (Bergvall-Kåreborn, Ihlström, Ståhlbröst, & Svensson, 2009). The QAS utilizes knowledge objects which essentially aim to encapsulate and tie a question to an information source that will provide an answer to a posted or posed question.

Within a LL knowledge is constantly created and classified as part of each of the factories' standard activities. Clark (2011) explains that artifacts (which could be seen as facts, concepts, processes, procedures, and principles) are often used in the process for the creation of new knowledge.

Various Living Lab activities are aimed at generating new knowledge or to extrapolate existing knowledge from other LL community members for use in various problem solving tasks. One way of generating new knowledge is through the application of standard research practices as depicted in Figure 1.

Within a LL environment there is close collaboration between both external and internal experts as well as internal and external knowledge seekers; this interaction is orchestrated through functionality provided as services in the NF.

Each of the factories that are part of the factory framework utilizes and generates new data, information, and knowledge for further processing and study. As knowledge applicable to the LL domain is created, the opportunity for the creation of new services is enhanced. New services are based on new concepts generated, which in turn are based on new facts obtained inter alia through the various research activities the practice of grounded theory, activity theory, action research, prototyping, and design and creation.

Knowledge Workers as Knowledge Agents in LLs

The knowledge activities of a LL are enabled not only by the various systems, services, and tools but also by the knowledge workers themselves. From an agricultural Community of Practice (CoP) perspective, extension officers will in most cases fulfill the role of knowledge workers. The term *knowledge worker* has different definitions presented from different perspectives. Efimova (2004, p. 3) explains that knowledge workers could be seen as investors of knowledge who make informed decisions on when and how much of their knowledge and energy to invest in a company, where the company does not necessarily have much control over the investments.

Mládková (2011, p. 248) explains that the quality of the work presented by knowledge workers, not only depends on their ability to create, distribute, and share the knowledge that they work with, but also on the way that the knowledge is organized and maintained in the organization and in this case the LL. The success of a knowledge organization could also depend on the way that tacit knowledge is maintained and disseminated, which is often problematic. The problems identified by Mládková (2011, p. 248) could be addressed by the implementation of the various LL knowledge support services.

Knowledge integration plays an important role in each of the factories. Zakaria (2011, p. 42) explains that the process of knowledge integration, which could be seen as the process of recombining existing knowledge for exploitation, is of key interest in the formation of new ideas. Existing knowledge undergoing knowledge integration leads to and promotes innovation.

The researchers believe that another cardinal aspect in any LL environment is that the generation of knowledge leads to the promotion and support of learning, which also catalyzes the knowledge-sharing activities amongst all LL stakeholders. Part of the objectives of the Knowledge Support Services is to promote learning through the provision of tools, of which the QAS is an example.

The Role of Learning in LL Environments

Learning in a Living Lab (LL) involves the Community of Practice (CoP), the individual knowledge seeker, and the idea of knowledge negotiation. The addition of meaning to existing practices is (in the researchers' opinion) what drives innovation in a living lab. Johansson, Snis, and Svensson (2011, p. 2) provide the following definition that aligns the notion of creation of meaning with that of a CoP in a LL environment: "Learning is described as an ability to negotiate new meanings within a CoP, to create engagement in CoP and to deal with boundaries between CoPs."

In view of this description the researchers support the notion that in LL environments, the learning process constantly adds knowledge to the LL knowledge base, therefore using pre-existing knowledge from the knowledge base can also aid in the generation of new knowledge. If the process of accessing pre-existing knowledge is adequately supported by the LL Knowledge Support Services, the knowledge acquisition learning process can be significantly enhanced.

Learning Objects, and Knowledge Objects in LL Environments

As indicated in the previous sections, learning and knowledge dissemination play a cardinal role in the envisioned functioning of a LL. This section of the paper presents an overview of two important concepts which facilitate and enable the various knowledge support activities envisioned, namely, learning objects and knowledge objects.

Learning Objects

The concept of a learning object (LO) is frequently encountered in literature relating to digital libraries, e-learning, instructional design, and classroom and experimental environments. Wiley (2000) explains that a LO should be regarded as any digital resource that can be reused to support learning which has been intentionally designed for learning purposes.

Strong (2012) highlighted the fact that the nature of learning objects should inherently be reusable and presented the concept of a re-usable LO, i.e. RLO, in the context of agricultural extension, by explaining that "a RLO is one low-cost, low-input method to teach Extension agents how to use the cognitive domain as a template to write educational objectives. RLOs are a stand-alone learning tool designed to focus on a singular learning objective." The notion of a Reusable Learning Object (RLO) is also presented by various other scholars (cf. Ashley, Davis, & Pinsent, 2008; Riley, 2012; Windle, Wharrad, Mccormick, Laverty, & Taylor, 2010).

Johnson (2003) of Macromedia explained that an e-learning object could comprise of a collection of digital materials which could be transferred by using communication technologies such as the Internet. Johnson also stressed that an e-learning object should have a clear and measurable learning objective, or it should be designed in such a way that it will support a standard learning process.

From the descriptions and definitions in literature referred to above, it is evident that LOs:

- may take on any digital form, such a video or audio clip, picture, animation, or text document which may be stored and retrieved from a database;
- have a clear and measurable objective associated with them, e.g., a video clip indicating which procedure to follow in accomplishing a given task such as planting a specific kind of crop;
- are reusable; and
- could be described and categorized using standard xml metadata formats.

Within an agricultural LL environment the use of Learning Objects could play a significant role in the teaching and learning processes of both extension officers and farmers, and significantly improve the knowledge support objectives.

Knowledge Objects

In literature there are different interpretations regarding how Knowledge Objects (KOs) and Learning Objects (LOs) relate to one another. There is no precise accepted definition for either one. McGreal (2004) contrasted the various concepts relating to LOs and KOs and highlighted the fact that a KO is sometimes regarded as a component of a LO. Others suggest a LO and a KO to be equivalent to one another (Merrill, 2000; Paquette & Rosca, 2002).

In a presentation relating to the Metaschool LLP Project (cf., lemil.net, 2011) the idea that a KO is a granular component of a LO is supported. The researchers are of the opinion that most of the predominant characteristics and attributes of LOs are also applicable to Knowledge Objects.

Merrill (2000) supports the idea that the KO concepts are broader than that of a LO, where LOs are more granulized and applicable in educational contexts, and that KOs often include only content and not an objective or some additional instruction information.

Paavola (2011) of the KP-Lab FP-6 project presents the following descriptions of a KO by explaining that KOs:

- are often referred to as knowledge artifacts where the knowledge artifact aims to fulfill a particular epistemic function (type of mediation) within the knowledge creation process;

- could also be seen as an 'epistemic object', where the knowledge object is created by a group of people and often presented in a visual form (Ewenstein & Whyte, 2009; Knorr-Cetina, 2008, p 89);
- may also be any kind of phenomenon or conceptual entity or a problem situation where the learning community aims to gain insight into for learning and innovation purposes; and
- might include a variety of diverse concepts and things such as academic theories, products but also processes and practices.

For this research, each of the descriptions provided by Paavola (2011) has a particular reference to a LL environment where:

- research artifacts in various forms, such as notes, questionnaires and results are often used and re-used in the generation of new knowledge by the user community;
- KOs could take on the form of, for example, a brochure, visual diagram, textbook or other digital knowledge presentations; and
- problem situations lead to questions that need to be addressed with solutions by applying best practices.

Anatomy of a KO – Researchers' perspective

Within the scope and description of this research the utilization of Knowledge Objects (KOs) are seen as one of the prime enablers of the knowledge support activities of a Living Lab (LL). KOs are also cardinal to the functioning of a LL, to promote effective and efficient extension services and positively contribute to annotation and stimulation of new knowledge generation.

The authors see a KO as being intrinsically tied to a question where the KO aims to address and supply an answer to a question posted by a knowledge seeker. The KO and a question are tied to an applicable domain, which may overlap areas of other knowledge domains. Where LOs often aim to collate and address a specific learning outcome, a KO aims to represent content. The content aims at providing sources that could provide an answer to a particular question. The KO aims to address questions such as *how, why,* and *what*. A KO is classified and described using semantic metadata for future access and interoperability. The KO itself is considered as a resource, just as a LO would.

Figure 2 illustrates how KOs relate to questions posed in the LL environment. The central idea is that a complete answer and/or solution are provided which is then tied to a question. Parts or a combination of parts of KOs could be classified and described to provide a solution to a question. It is also possible that a KO could provide complete answers to more than one possible question.

It is foreseeable that not all questions posted or posed would be answered by means of the available KOs which form part of the LL knowledge repository. In such cases applicable LL research methods as depicted in Figure 1 will have to be initiated to aim to answer the questions posted. In other situations existing KOs could be revaluated and adapted by experts to provide a complete answer to a question. Various techniques could be applied, e.g., combination, internalization, the addition of annotations, and new patterns generation.

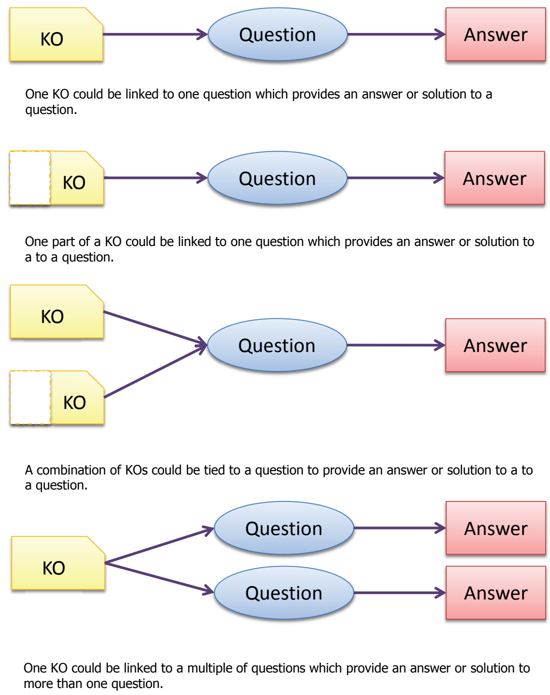

Figure 2 – Relation between KOs, questions, and answers

Existing KOs could be reclassified and reworked to provide a full answer to a question, which was not described before. The KO itself is not changed, only the interpretation of the information and tags could provide new insight. Research activities could also generate and create new KOs. Figure 3 highlights this concept.

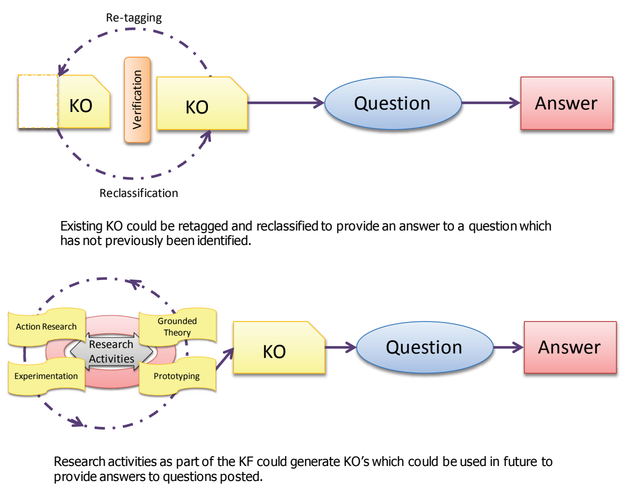

Figure 3 – Generating and reworking KOs

For the purposes of this study the focus is placed on all non-physical sources of knowledge that could be captured and classified in a digital format.

KOs as Sharable Content Objects

The notion of a KO and its use within a LL environment has been described. Figure 4 presents some additional examples and highlights the concept that KOs could be seen as digital assets. This is similar to Sharable Content Objects (SCO) implemented as part of the Sharable Content Reference Model (SCORM). SCOs are often aggregated into collections of activities that may contain other collection aggregations or other SCOs.

Yaghmaie and Bahreininejad (2011) explain that Sharable Content Objects (SCOs) form the basis of the SCORM model in which SCOs are digital assets in various formats such as sound clips, text videos, and images. The American Department of Defense and the Advanced Distributed Learning group (cf., ADL, 2011, p. 12) explain that a SCO is the smallest unit of lesson content. It aids learning as part of a learning management system and each SCO is described by the XML based LOM standard.

Figure 4 presents the idea that a KO, like a SCO, could also be aggregated. The principle concept behind aggregations is the grouping of related content, which aims at enhancing the learning process by conveying the same content with different assets in different formats.

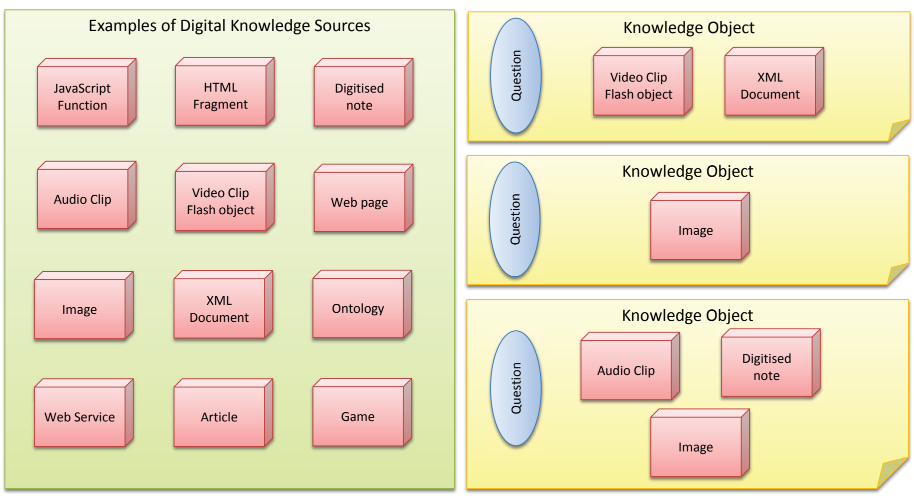

Figure 4 –Examples of KOs

Balatsoukas, Morris, and O'Brien (2008) point out that SCO aggregations are often tied to lessons which in turn are part of modules in a course. Lessons are tied to the curricula and aim to address a particular learning outcome. For the researchers, the main differentiation between a SCO and a KO is the notion that a KO is intrinsically tied to a question rather than a learning outcome.

Describing KOs

Over the years various standards and technologies have evolved to describe the metadata of digital sources such as Extensible Markup Language (XML) and Resource Description Framework (RDF) which includes OWL. Ontologies are also increasingly becoming popular as the semantic web (WEB 3.0) is constantly evolving and becoming more popular by the day.

Various knowledge models, such as ontologies, use different tools to describe the content presented. One of the oldest and most popular ontologies is the Dublin Core (DC) ontology, provided by the Dublin Core Metadata Initiative (DublinCore.org, 2012)

Kim et al. (2011) describe the DC Ontology as a Metadata Element Set which is a standard for cross-disciplinary resource description where the semantics of the 15 elements of the Dublin Core (i.e., title, subject, description, creator, publisher, contributor, date, type, format, identifier, source, language, relation, coverage, and rights) are described by using a combination of standards, including XML and RDF.

Esteban-Gil, Fernández-Breis, Castellanos-Nieves, Valencia-García, & García-Sánchez (2009), however, argue that SCORM which incorporates the use of SCOs could be seen as the most important Learning Object standard used in e-learning systems. Baldoni, Baroglio, Patti, & Torasso (2004) point out that the LOM metadata schema acts as the basis on which SCORM classifies and describes SCOs which utilize XML. In research presented by Buitendag and van der Walt (2011a) it was highlighted that KOs could be classified using metadata wrappers, based on existing ontologies.

By using the collaborative efforts of various agricultural extension officers, existing web based documents in different formats could be tagged and annotated with relation to specific cases, utilizing standard ontologies and metadata wrappers. In order to facilitate the representation of web papers in various forms, Garcia-Crespo, Gomez-Berbis, Colomo-Palacios, & Garcia-Sanchez (2010) developed the Paper-Of-A-Paper (POAP) ontology. The POAP ontology represents the network of concepts and associated external resources derived from the tagging activity of related web documents. The POAP ontology is modeled on the Friend-Of-A-Friend (FOAF) ontology which facilitates interaction and interrelations based on people's connections and friends.

An important consideration for this research is the fact that each ontology and metadata model implements a unique identifying field. In the case of ontologies, this unique identifier is realized through utilizing URIs and RDF IDs. The Identity of Resources on the Web (IRW) ontology was specially developed to aid the description of various URIs

KO Wrappers Using JSON

Another ever increasing and popular technology that could be used to describe metadata is JavaScript Object Notation (JSON). JSON is a lightweight data-interchange format, which is both human readable and easy for machines to parse and generate ("Introducing JSON," n.d.). JSON is a language-independent data interchange format that provides a simple text representation of arbitrary data structures (Google Developers, 2012). The JSON standard is a popular technology for consuming content via an Application Programming Interface (API) provided by various vendors and software services (JSON Format, 2012).

An API is a set of functions, routines, and protocols published by an enterprise or public application, for use by other developers in the development of services and other software tools. APIs are often accessible over the Internet as web services. Within a Living Lab (LL) the Service Factory promotes the development of custom services by using existing services through APIs. Utilizing existing APIs from service providers in the development of custom tools provides a unique opportunity for service development in a LL.

Many popular web based software services and tools, e.g., Delicious.com (for social bookmarking), Digg.com (for news and bookmarking) as well as Zotero (for research purposes) use JSON as the interchange format. This is particularly appealing to this research due to the fact that JSON could be used as a data format for the description of a Knowledge Object Wrapper (KOW).

Figure 5 presents the researchers' simple class diagram model that represents the basic structure of a KOW, which is implemented as part of the knowledge support services of the LL.

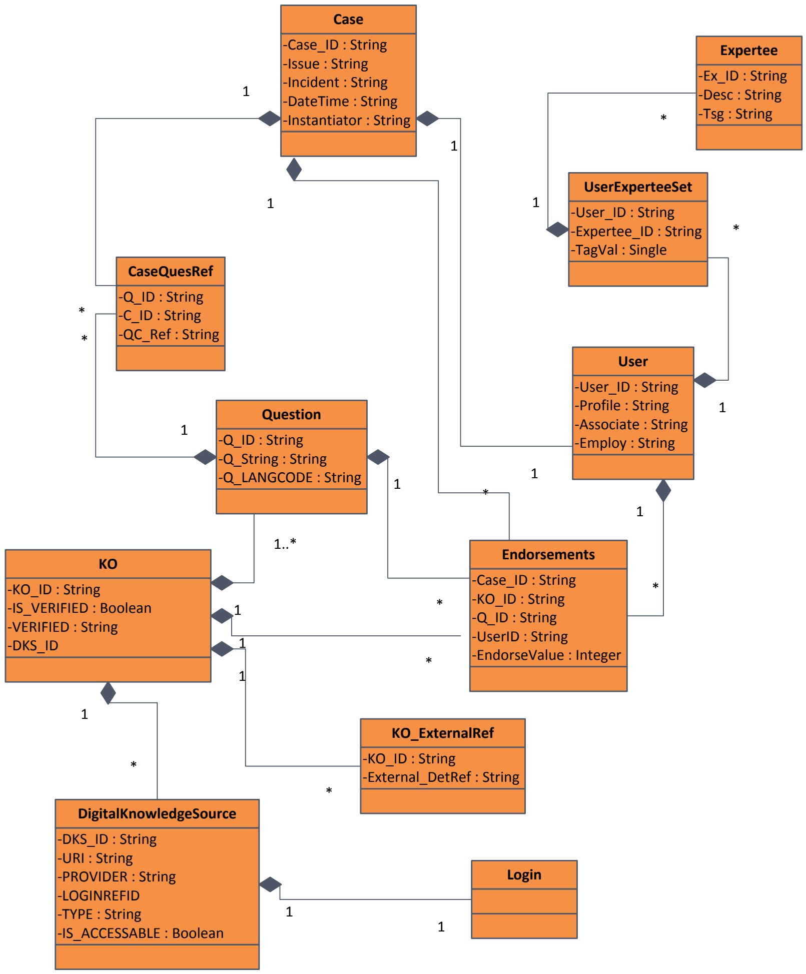

Figure 5 – Diagrammatic overview of a KO class wrapper model

In essence a KOW adds an 'additional layer' to current metadata models, with the specific objective to also include questions as metadata. Questions are tied to unique cases, which are also referenced as part of the metadata. The main idea behind the implementation of the KOW is not to substitute or replace existing metadata models, but to extend the models with new functionality. We believe that the implementation of questions in conjunction with standard tags and tagging operations would not alter the operations or intended design of exiting models, but would add an additional metadata dimension. The additional dimension which could add contextual data would be beneficial for both knowledge seekers as well as the knowledge workers.

The Knowledge Object (KO) is represented by the main class. Each KO is uniquely identified by an ID field and is tied to a particular case which references a knowledge request instance posted by a knowledge seeker. Each object is marked as being verified or not. If the object was verified, it contains a link pointing to the external expert who has verified if the applicable Digital Knowledge Source (DKS). The verification process aims at ensuring that each DKS does indeed provide an applicable and correct answer posted or referenced as the result of a question.

Each KO is tied to a single question; multiple questions are represented as new KOs with a common case reference. Therefore, a common case could refer to many questions with many aggregated DKSs. Some important aspects of a DKS are that:

- it closely correlates to a SCO, where there could be reference to a multiple of digital assets;
- in contrast with a SCO, a DKS is not tied to a learning outcome, but rather to a specific question; and
- a DKS comprises of a unique identifier i.e. a URI field which is the de facto standard for referring to various digital resources, located on the web.

The provider field refers to the name of the content provider. In certain cases logon details will be required for access, and in such instances the Login object will store and access the required verification details by implementing standard authentication protocols. The type is used to indicate the format of the digital resource and is often required to identify the asset and to access the content for instance .pdf readers and .flv players.

The researchers believe that the utilization of questions as an additional meta-tag may provide benefits by:

- presenting additional context to the KO relating to the scope and content;
- allowing better analysis and contextualization of the existing tags; and
- tying in additional semantic constructs, in the form of linguistics.

Figure 6 presents an example of a Knowledge Object Wrapper (KOW) in the JSON format and represents a KO that aims to provide resources to answer the question: *"How is a cow milked by hand?"* In the example the question is tied to a specific case, and various assets are referenced that could be used to aid in answering the question posted.

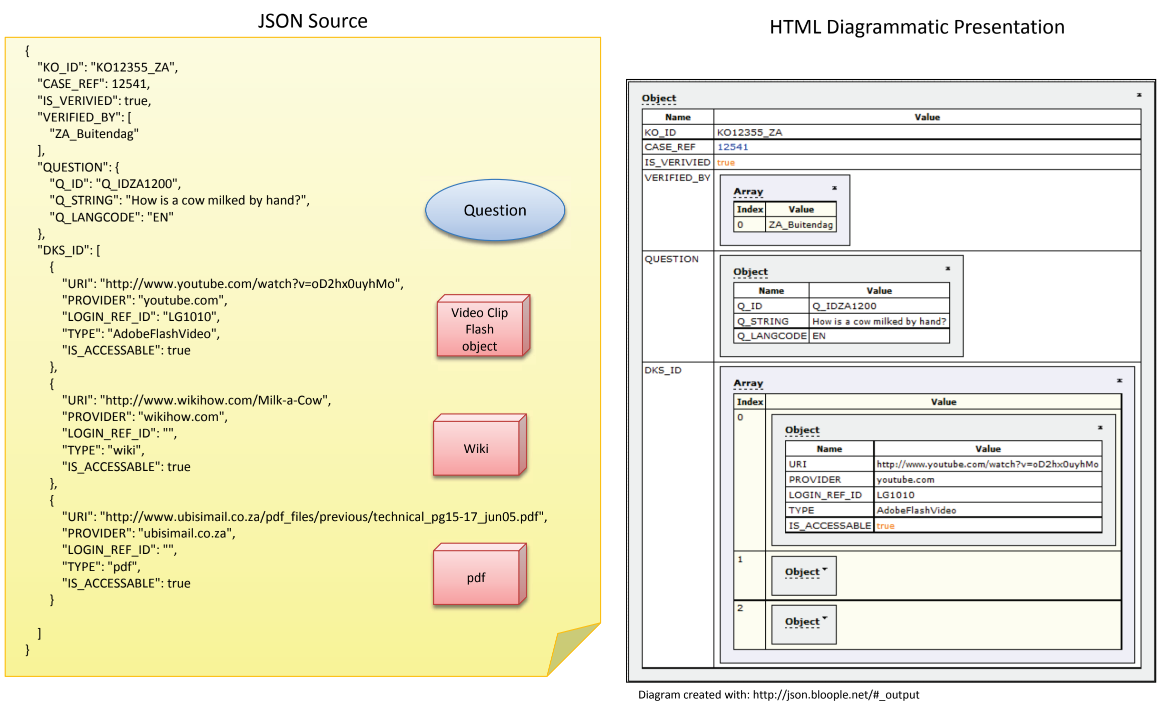

Figure 6 – KO Wrapper represented in JSON and an equivalent HTML representation

Figure 6 draws in with the concepts as presented in Figure 5, where a KO ties to a question providing a solution or answer. Another important aspect of the KO Wrapper is the capability of users to endorse the KO relating to the assets and the question. Allowing users to endorse the KO, will promote the reusability as well as ensuring quality and validity.

Implementing KOs as Part of the Question & Answer Service

Figure 7 presents the general flow and composition of the Question and Answer Service (QAS) as one of the knowledge support services provided for use by the Living Lab Knowledge Factory. The Semantic/Metadata integration service implements KOs and a process for the generation and maintenance of existing KOs. The knowledge support activities in a LL are dependent on the collaborative efforts of both the knowledge seekers as well as the knowledge experts (i.e., knowledge workers) and in the case of an agricultural CoP, the extension officers.

The QAS utilizes KOs, as depicted in Figure 7, by means of a knowledge seeker posting a question to the service, which could be hosted on a standard collaboration platform or social media tool utilized by the LL, e.g., Facebook. An analytics service evaluates and analyzes the question posted and allows for a search with semantic matching in an existing semantic repository. The analytics service implements a question and answer extrapolation tool (QAET) to match and search existing KOs, based on keywords supplied in the question as well as the question itself.

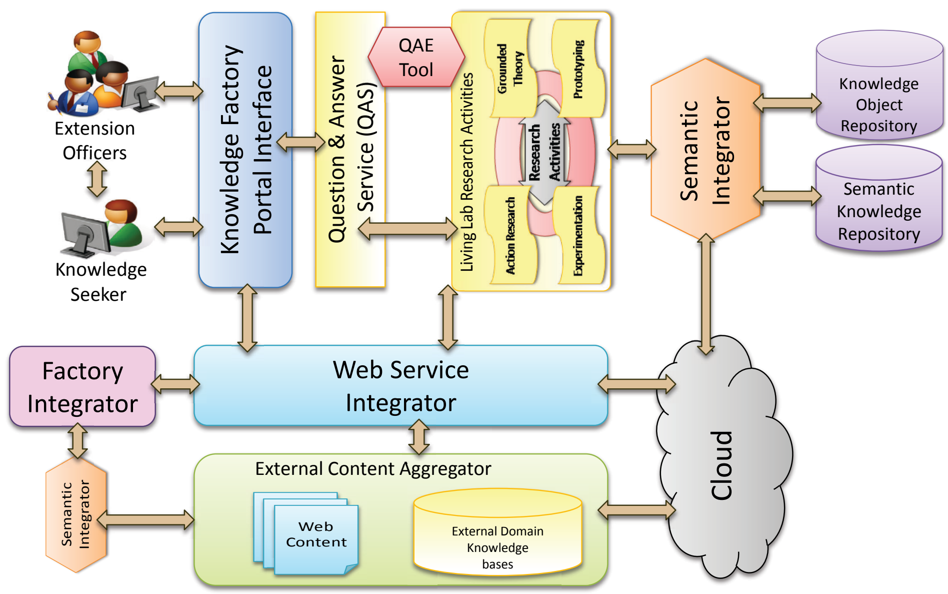

Figure 7 – Knowledge support framework and the QAS service

The QAET operates as follows:

- A posted question or request is dissected and broken down into common sentence units, such as verbs, adjectives and nouns.
- The text mining service analyses the sentence parts and performs an initial matching activity with prior questions that were stored within the Questions and Answer Repository.
- The nouns are compared to existing tags within sources in the repository.
- Similarities and AI matching methods are applied and matching result-sets from the Question and Answer repository are returned.
- The returned result-set and original question is then further analyzed by utilizing Natural Language Processing tools and services.

- The result-set which comprises of exiting DKS (Digital Knowledge Source) references as well as previous question postings tied to the DKS, is presented.
- The knowledge seeker has the opportunity to review the result set and suggested answers presented by the response (QAS) service.

As part of the review process, the referenced sources in the KO, such as video, pdf, and web page, are called and rendered in an applicable browsing area. Some DKSs could be stored locally as part of the Knowledge Object Repository (KOR). Both the knowledge seeker and external experts have the opportunity to validate and verify the content, i.e., answers (solutions) of the result set, which represents the existing knowledge.

The practice of verification is important to ensure that KOs reference DKSs that do indeed supply correct answers to the question posted. In cases where the DKSs are not accessible, the applicable indication is adjusted as part of the KO wrapper. The Semantic Knowledge Repository acts as a catalogue mechanism where JSON knowledge wrappers are stored. The Knowledge Object Repository stores local KO data such as documents, videos, notes as well as previously downloaded content from other sites.

The semantic metadata integrator provides functionality for the semantic extrapolation process. This process generates tags which are compared with existing metadata, using semantic pattern clustering in the Semantic Knowledge repository, which matches existing classes, relations, axioms, functions and instances of prior searches and results.

Conclusion

The process of conducting research in a Living Lab environment generates new information that needs to be classified and appropriately applied to answer not only the current research questions but also those that may arise in the future.

The operation of the Question Answer Service (QAS), the role of the knowledge workers as well as the quality of the meta data used that ties questions to possible answers, will determine how effective the LL is in solving problems of the community it is serving.

In revisiting the main research question presented, the researchers highlighted the role and benefits questions may play if used as metadata tags in conjunction with standard metadata in the form of a Knowledge Object Wrapper. In this paper we suggest and support the idea that a KO could be implemented as part of a LL environment to provide an additional dimension to the management and categorization of knowledge based on questions. By implementing this approach the researchers suggest that the various knowledge worker activities will be greatly catalyzed, and that the implementation of the knowledge support framework with enable this practice, of efficient knowledge generation, storage and dissemination. This paper has argued that the additional dimension and the utilization of JSON for the description of metadata wrappers will not only enable interoperability but also provide a unique approach to the storage of information and knowledge references.

References

ADL. (2011). *SCORM users guide for programmers – SCORM 2004.Version 10*. American Department of Defense and Advanced Distributed Learning Group. Retrieved 10 October, 2012 from http://www.adlnet.gov/wp-content/uploads/2011/12/SCORM_Users_Guide_for_Programmers.pdf

Amour, J. (2011). *Commercial agriculture's expectations from extension & advisory services*. Presentation to Free State Agriculture: Presented: 10/26/2011

Ashley, K., Davis, R., & Pinsent, E. (2008). *Significant properties of e-learning objects (SPeLOs).* Report by JISC Information Environment Committee under the Information Environment strategic theme. Draft Version: 0.91. University of London Computer Centre. Retrieved 14 May, 2012 from http://www.jisc.ac.uk/media/documents/programmes/preservation/spelos_report.pdf

Balatsoukas, P., Morris, A., & O'Brien, A. (2008). Learning objects update: Review and critical approach to content aggregation. *Educational Technology & Society, 11*(2), 119-130. Retrieved 8 November, 2012 from http://www.ifets.info/journals/11_2/11.pdf

Baldoni, M., Baroglio, C., Patti, V., & Torasso, L., (2004). Reasoning about learning object metadata for adapting SCORM courseware. *Proceedings of EAW'04*, pp. 4–13. Retrieved 14 November, 2012 from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.81.690&rep=rep1&type=pdf

Bergvall-Kåreborn, B., Ihlström, C., Ståhlbröst, A., &Svensson, J. (2009). A milieu for innovation - Defining living labs. *2nd ISPIM Symposium,* New York, 6-9 December, 2009 Retrieved 29 February, 2012 from http://pure.ltu.se/portal/files/3517934/19706123_Paper.pdf

Buitendag, A. A. K. (2013). *Living Labs for knowledge support*. D-Tech dissertation, work in progress.

Buitendag, A. A. K., Hattingh, F. G., & van der Walt, J. S. (2012). Current Web 2.0 and Web 3.0 API provisions for tool and service development using a Living Lab approach. *Proceedings of the ZA-WWW, 2012 conference*, November 7-9, 2012. Durban (South Africa). Retrieved November 10, 2012, from http://www.zaw3.co.za/index.php/ZA-WWW/2012/paper

Buitendag, A. A. K., & van der Walt, J. S. (2011a). Presenting a framework for knowledge support for use within a web enabled Living Lab. *Proceedings of the ZA-WWW, 2011 conference*, September 14-16 September. 2011. Johannesburg (South Africa). Retrieved February 19, 2012, from http://www.zaw3.co.za/index.php/ZA-WWW/2011/paper/view/401/119

Buitendag, A. A. K., & van der Walt, J. S. (2011b). Utilising grounded theory research techniques to catalyze knowledge discovery within a living lab environment. In K. Charvat & T. Mildorf (Eds.), *ICT for agriculture - Where we are? Where we will go?* (pp. 70-85). Prague: Czech Centre for Science and Society.

Buitendag, A. A. K., van der Walt, J. S., Malebane, T., & De Jager, L. (2012). Addressing knowledge support services as part of a living lab environment. *Issues in Informing Science and Information Technology, 9*, 221-241. Retrieved June 12, 2012, from http://iisit.org/Vol9/IISITv9p221-241Buitendag123.pdf

Clark, D. (2011). *Learning with artifacts*. Retrieved March 3, 2012, from http://www.nwlink.com/~donclark/learning/artifacts.html

Cunningham, P., Herselman, M., & Cunningham, M. (2011). *Supporting the evolution of sustainable living labs and living lab networks in Africa*. Ireland: IIMC International Information Management Corporation.

Demby, D. (2012). Building a continental online platform for agricultural information and knowledge sharing in Africa. *Proceedings of the 3rd IAALD Africa Chapter Conference –e-Agriculure for improved livelihoods and food security in Africa*. 21-23 May Johannesburg, South Africa

DublinCore.org. (2012). *Dublin Core Metadata Element Set, Version 1.1*. Retrieved November 11, 2012, from http://dublincore.org/documents/dces/

Efimova, L. (2004). *Discovering the iceberg of knowledge work: A weblog case*. Retrieved April 4, 2012, from https://doc.telin.nl/dsweb/Get/Document-34786

Esteban-Gil, A., Fernández-Breis, J. T., Castellanos-Nieves, D., Valencia-García, R., & García-Sánchez F., (2009). Semantic enrichment of SCORM metadata for efficient management of educative contents. *Procedia - Social and Behavioral Sciences, 1*(1), 927-932. Retrieved November 11, 2012, from http://www.sciencedirect.com/science/article/pii/S1877042809001670 I

Ewenstein, B., & Whyte, J. K. (2009). Knowledge practices in design: The role of visual representations as 'epistemic objects'. *Organization Studies, 30*(1), 7-30. Retrieved May 14, 2012, from http://centaur.reading.ac.uk/11980/1/2009_OS_Ewenstein_%26_Whyte_Knowledge_practices_in_design_submitted.pdf

Garcia-Crespo, A., Gomez-Berbis, J. M., Colomo-Palacios, R., & Garcia-Sanchez, F. (2010). Digital libraries and Web 3.0. The Callimachus DL approach. *Computers in Human Behavior, 27*(4),1424-1430.

Google Developers. (2012). *Blogger JSON API: Getting Started*. Retrieved October 13, 2012, from https://developers.google.com

Herselman, M. E., Marais, M. A., & Pitse-Boshomane, M. M. (2010). Applying living lab methodology to enhance skills in innovation. *Proceedings of the eSkills Summit 2010*. Cape Town, 26-28 July 2010, pp 7

Introducing JSON. (n.d.) Retrieved 1 August 2012 from http://json.org

Johansson, L.,.Snis, U. S., & Svensson, L. (2011). The dynamics of interaction: exploring a living lab innovation process from a community of practice perspective. *PACIS 2011 Proceedings*, Paper 85. Retrieved 29 February, 2012 from http://aisel.aisnet.org/pacis2011/85

Johnson, L. F. (2003). *Elusive vision: Challenges impeding the learning object economy*. Retrieved 6 May, 2012 from http://download.macromedia.com/pub/solutions/downloads/elearning/elusive_vision.pdf

JSON Format. (2012). Retrieved 27 November 2012 from http://jsonformat.com/

Kim, H. L., Scerri, S., Passant, A., Breslin, J., Handschuh, S., Decker, S., & Kim, H. G. (2011). Integrating tagging into the web of data: Overview and combination of existing tag ontologies. *Journal of Internet Technology, 12*(4), 561-571. Retrieved 10 November, 2012 from http://www.johnbreslin.org/files/publications/20110700_jit_2011.pdf

Knorr-Cetina, K., (2008).Objectual practice. InM. Mazzotti (Ed.), *Knowledge as social order - Rethinking the sociology of Barry Barnes* (pp. 83-98). Hampshire, England: Ashgate Publishing. Retrieved 14 May, 2012 from http://wxy.seu.edu.cn/humanities/sociology/htmledit/uploadfile/system/20100829/20100829132516333.pdf#page=98

Kusiak, A. (2007). Innovation: The living laboratory perspective. *Computer-Aided Design & Applications, 4*(6), 863-876. Retrieved 4 April, 2009 from www.icaen.uiowa.edu/~ankusiak/Journal-papers/CAD_07.pdf

LLiSA. (2011). *Living Labs South Africa*. Retrieved 12 March, 2011 from http://llisa.meraka.org.za/index.php/Living_Labs_in_Southern_Africa

McGreal, R. (2004). *Online education using learning objects*. London: Routledge/Falmer.

Mládková, L. (2011). Knowledge management for knowledge workers. *The Electronic Journal of Knowledge Management, 9*(3), 248-258. Retrieved April 20, 2012, from www.ejkm.com/issue/download.html?idArticle=296

Merrill, M. D. (2000). Knowledge objects and mental-models. *Proceedings of the International Workshop on Advanced Learning Technologies*, Palmerston North, New Zealand. Retrieved 14 May, 2012 from http://lttf.ieee.org/iwalt2000/slides/merrill_2.ppt

Paavola, S. (2011). *KP-lab project – Knowledge object description*. Retrieved 14 May, 2012from http://kplab.evtek.fi:8080/wiki/Wiki.jsp?page=KnowledgeObject

Paquette, G., & Rosca, I. (2002). Organic aggregation of knowledge object in educational systems. *Canadian Journal of Learning and Technology, 28*(3). Retrieved May 13, 2012, from http://www.cjlt.ca/index.php/cjlt/article/view/111/104

Purdy, D. (2002). *Exploring the factory design pattern*. Retrieved February 10, 2012, from http://msdn.microsoft.com/en-us/library/ee817667.aspx

Riley, F. (2012). *Reusable Learning Objects (RLOs) - Learning Objects for Healthcare by School of Nursing, Midwifery and Physiotherapy, University of Nottingham.* Retrieved 6 May, 2012 from http://sonet.nottingham.ac.uk/rlos/index.php

Strong, R. (2012). Reusable learning objects enhanced master goat producers' learning. *Journal of Extension, 50*(2), Article Number 2RIB7. Retrieved 6 May, 2012 from http://www.joe.org/joe/2012april/pdf/JOE_v50_2rb7.pdf

van Der Walt, J. S., Buitendag, A. A. K., Jansen Van Vuuren, J. C., & Zaaiman, J. J. (2009). Living lab as a collaborative innovation environment. *Issues in Informing Science and Information Technology (IISIT), 6*, 421-436.

Wiley, D. (2000). Connecting learning objects to instructional design theory: A definition, a metaphor, and a taxonomy. In D. A. Wiley (Ed.), *The instructional use of learning objects*. Retrieved 5 May, 2012 from http://reusability.org/read/chapters/wiley.doc

Windle, R. J., Wharrad, H., Mccormick, D., Laverty, H., & Taylor, M. (2010). Sharing and reuse in OER: experiences gained from open reusable learning objects in health. *Journal of Interactive Media in Education (JIME)*. Retrieved 15 May, 2012 from http://jime.open.ac.uk/jime/article/viewArticle/2010-4/html

Yaghmaie, M., & Bahreininejad, A. (2011). A context-aware adaptive learning system using agents. *Expert Systems with Applications. 38*(4), 3280-3286. Retrieved 19 June, 2012 from http://dx.doi.org/10.1016/j.eswa.2010.08.113

Zakaria, N. H. (2011). *The impact of knowledge integration on enterprise knowledge success*. PhD Thesis. Queensland University of Technology.

Biographies

Bertie Buitendag is currently enrolled for his D-Tech in Enterprise Application Development at TUT under the supervision of Prof JS van der Walt. His core research area includes ICT Knowledge support for emergent farmers and Living Labs. Other areas of interest include the: Semantic Web, (WEB 3.0) and WEB 2.0, and ICT's for community upliftment.

Fredre Hattingh is currently enrolled for his M-Tech in Technical Applications at TUT. His research interests include Living Labs, Virtualization and Plagiarism detection. Other areas of interests include Open Source Software and emerging technologies.

Prof. Jacobus (Potjie) van der Walt has been intensively involved into ICT research over the past 30 years at the Tshwane University of Technology (TUT). His core research interests currently pertain into the study of emergent community-oriented ICT support, with specific reference to portal based applications for emergent farmers. He has successfully supervised numerous post graduate students. He was also one of the first academia in South Africa to publish a paper regarding community oriented Living Labs. He also started the Soshanguve LL initiative.