The Fifth International Conference on e-Learning(eLearning-2014), 22-23 September 2014, Belgrade, Serbia

AN INTRODUCTION TO THE ITEC SCENARIO DEVELOPMENT ENVIRONMENT

LUIS ANIDO-RIFON
University of Vigo, Department of Telematics Engineering, lanido@det.uvigo.es

ROBERTO PEREZ-RODRIGUEZ
University of Vigo, Department of Telematics Engineering, roberto.perez.rodriguez@gmail.com

MIGUEL GOMEZ-CARBALLA
University of Vigo, Department of Telematics Engineering, ks9mikel@gmail.com

MARCOS MOURIÑO-GARCIA
University of Vigo, Department of Telematics Engineering, marcosmourino@gmail.com

Abstract: *This paper describes the Scenario Development Environment, a Web application that enables users to find, select, and combine educational resources.The main distinctive feature of the SDE is that documents in the system are represented by the concepts they contain, rather than by the words they contain—as in traditional information retrieval systems. Software agents perform the task of creating semantic annotations of documents, thus creating the concept-based representation of documents automatically. The concept-based approach is particularly well suited for enabling exploration of the space of concepts, by navigating from an educational resource to others that have a common semantic annotation, and also for exploring semantically related resources. Besides, the SDE provides convenient functionalities for gathering resources while performing an exploratory search, and for combining them afterwards, in a sort of "learning story".*

Keywords:*Information Retrieval, Bag-of-Concepts Document Representation, Exploratory Search*

1. INTRODUCTION

In the past few years, technology is playing an increasingly important role in classrooms. Thus, governments, ministries of education, and entities with competences in education are launching programs that aim at providing classrooms with technological infrastructure.

The availability of technologies in the classroom opens up a world of possibilities for the teaching practice. However, in spite of the great potential of technology-provided classrooms, a big part of them remain underused. In the literature, we can find several reasons for that:

- The first one is that technology does not fit well traditional teaching approaches—those based on master classes, in which technology is perceived as a distracting element.
- The second one is that teachers lack training on how to effectively use technologies in their teaching practice. Training has a twofold dimension: pedagogical and technological.

As a step towards overcoming those problems, several research groups working together within the framework of the iTEC project have proposed a series of pedagogical approaches, which have been tested in large-scale pilot experiences throughout Europe. Those pedagogical approaches emphasise the importance of teacher training for their adequate implementation.

The cornerstone of those approaches is the so-called Future Classroom Scenario, conceived as a small cooperative project in which students, working in groups, carry out several Learning Activities. In those Learning Activities—in addition to the contents of the curriculum—students practice the so-called XXI Century Skills, such as: working cooperatively, using technology, and speaking in public.

The final outcome of iTEC is an integrated set of tools grouped under the name of Future Classroom Toolkit, especially designed to facilitate the implementation of iTEC pedagogical approaches. The software tools created under the umbrella of iTEC—aimed at facilitating the process of defining and planning new Future Classroom Scenarios, as well as adapting existing ones—are a key part of the Future Classroom Toolkit. More concretely, iTEC has among its objectives "To build a prototype assistant for advising users how to find, select and combine resources that support the project scenarios"[1]. That software application is called the Scenario Development Environment (SDE), and it can be accessed at:

http://www.itec-sde.net

The approach followed in the SDE for enabling the discovery of educational resources is based on exploratory search. In an exploratory search, the search terms denote a concept—understanding concept as a *unit of knowledge*[1]. Retrieving documents in which a

[1]iTECDoW, page 11.

specific concept is relevant presents serious difficulties, which have to do with synonymy and polysemy:

- As spotted by [2], when the search terms are different from the terms used in a particular document, that document will not be retrieved. That is to say, synonymy negatively affects recall.
- Besides, polysemy negatively affects precision. When a user is searching for documents about planet Mercury, the retrieved documents that are about the chemical element called mercury have to be seen as an imprecision of the search engine.

The rest of this paper is organised as follows. Section 2 presents the concept-based representation of documents used in the SDE, which is fundamentally different from traditional representations on bag-of-words. Section 3 describes how to find educational resources by performing an exploratory search. Section 4 outlines the selection of resources. Section 5 explains how to combine learning resources in a sort of «learning story». Section 6 presents some evaluation results with end-users. Finally, Section 7 presents some conclusions.

2. CONCEPT-BASED REPRESENTATION OF DOCUMENTS

Fundamentals

In traditional information retrieval systems, documents are represented in accordance with the bag-of-words paradigm. Let's suppose that we have two text documents:

- Document A: "mercury is a chemical element".
- Document B: "Mercury is a planet of the solar system".

On the basis of the two documents above, we can build the following dictionary: "mercury": 1; "is": 2; "a": 3; "chemical": 4; "element": 5; "planet": 6; "of": 7; "the": 8; "solar": 9; "system": 10.

Following with this representation, documents are represented as vectors—with as many dimensions as entries in the above dictionary:

- Document A = [1, 1, 1, 1, 1, 0, 0, 0, 0, 0]
- Document B = [1, 1, 1, 0, 0, 1, 1, 1, 1, 1]

In this way, when a user introduces the term "mercury" the search engine checks the representation vectors and returns documents A and B—being document A completely irrelevant for a user that is looking for information on planet Mercury.

Automatic extraction of concepts

To know what concepts are referenced in a text document is a non-trivial task. Traditional approaches to this problem are based on using humans for generating the so-called *semantic annotations*[3], which are chosen from a set of possible annotations called taxonomy.

The principal problem with "manual" annotations is that is does not scale well. The generation of manual annotations is very time-consuming and error-prone. In order to overcoming that, some authors have proposed the automatic extraction of concepts from text documents, using techniques from the fields of Natural Language Processing and Machine Learning [4], [5]. Following that approach, given a text document, a software component "extracts" the concepts that particular document refers to.

In the literature, we can find several examples of automatic extraction of concepts [6]–[8]. [4]propose a method called Explicit Semantic Analysis (ESA), by which any text document is represented as a weighted vector of concepts from Wikipedia. The authors chose Wikipedia because it is the greatest repository of knowledge in the entire Internet. Evaluation of the effectiveness of this approach was performed by comparing its performance in the task of computing semantic relatedness between text documents to the traditional bag-of-words approach, concluding that ESA gives better results than the traditional method.

In a similar line, [9] represent documents on the basis of concepts from Wikipedia, to be used in the Koru search engine. According to the authors, Wikipedia is very suitable for this task, because it contains a big number of terms, with relationships between terms that have been added manually and are domain-independent.

Other systems build on resources different from Wikipedia for their concept-extraction task. Thus, [10] derive the concepts for representing documents from linguistic resources such as WordNet and WordNetDomain.

3. FINDING EDUCATIONAL RESOURCES

Suggesting concepts

The interaction with the system starts with the introduction of some search term in the search box. Thus, following with the example proposed in the introduction we can introduce the search query "tesla". As it can be seen in the Figure, "tesla" may refer to several different concepts. Hence, retrieved resources may relate to any of those concepts. As a consequence, for the particular case of the query "tesla", we can see among the search results some resources that refer to, among others:

- Nikola Tesla.
- Tesla, the international unit of magnetic fluid density.
- Tesla, the car manufacturer.

Seeing concept summaries

When we select a concrete concept from the list of suggested concepts, only the resources about that particular concept are displayed—all the rest are filtered. Thus, if we select the concept "Nikola Tesla", all the resources about "Tesla (unit)", "Tesla Motors", and "Nvidia Tesla" are filtered.

As it can be seen in the Figure, the grey box at the top of the page displays information on the concept "Nikola Tesla": a short paragraph describing his life and works; a representative picture of Nikola Tesla, a portrait concretely; and also a list of key-value pairs that relate Nikola Tesla to other concepts. That list of key-value pairs allows users to explore the graph of concepts. For instance, from the concept "Nikola Tesla" we can navigate towards the concepts "Induction motor", "Rotating magnetic field", and "Tesla coil", which are taken from Tesla's area of work; but we can also navigate towards "Smiljan" and "New York City", which are, respectively, the places where Nikola Tesla was born and died.

This way of interacting with the system described in the paragraph above is called Exploratory Search through the Space of Concepts, since from a particular concept we can keep on exploring through other related concepts.

After the description of the concept "Nikola Tesla", the system displays a list of the educational resources that have been annotated with the concept "Nikola Tesla". We can see, among other categories and resources:

- Places of interest, such as the Nikola Tesla museum in Belgrade.
- Biographies, such as the one of Nikola Tesla.
- Lectures, including the talk delivered by Marco Tempest entitled "The electric rise and fall of Nikola Tesla" in TED.
- Documentaries, including the ones: "The eye of the storm - Tesla", "Lost lightning: the missing secrets of Nikola Tesla", "Nikola Tesla – The genius who lit the world", "Nikola Tesla – The greatest mind ever", and "The electricity war".
- Books, such as: "Makers of electricity" by Bother Potamian, "Inventions, researches, and writings of Nikola Tesla" by Thomas Commerford Martin, and "Experiments with alternate currents of high potential and high frequency" by Nikola Tesla.

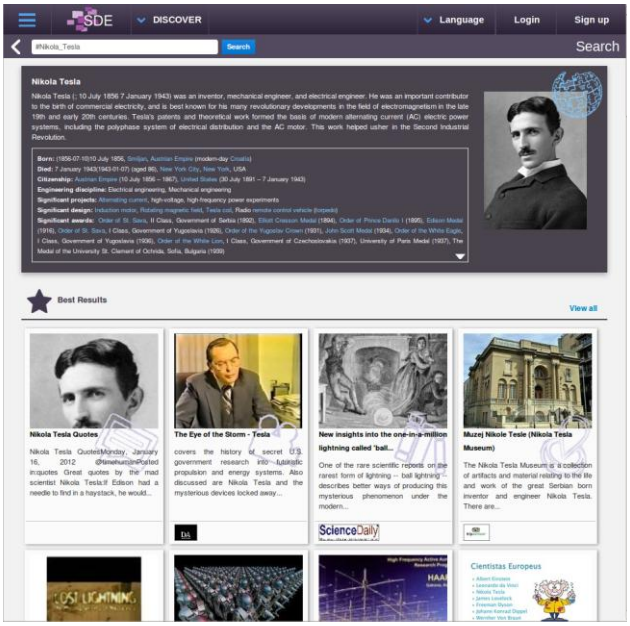

Image 1: Detail of the concept "Nikola Tesla".

Detail of an educational resource

When a user chooses an educational resource from the search results, the system displays a summary of that educational resource—which includes a brief extract from its textual content, a representative image (in case it is available), plus metadata of the educational resource. Besides that, the system shows the tags that have been automatically generated, and that correspond with the bag-of-concepts representation of the resource. Each of those tags is a navigable link, in such a way that clicking on a tag the user can navigate to a concept summary—and to the relevant resources for that concept.

The behavior described above is called exploratory search through the space of tags. This kind of exploratory search works seamlessly in conjunction to the exploratory search through the space of concepts.

The exploratory search through the space of tags is inspired in social tagging sites such as Del.icio.us, Flicker, or even Twitter and Instagram. For instance, in Del.icio.us, users assign tags to the resources that they incorporate into the platform; and those tags are navigable—clicking on a particular tag, other resources that were assigned the same tag are retrieved. In Flickr, where users assign descriptive tags to pictures, the same mechanism is applied. In all those systems that implement social tagging the exploration of new documents through tags is natural and convenient.

A similar approach is used in repositories of educational resources such as Klascement, in which users assign tags to the educational resources that they aggregate to the repository, and those tags may be used for exploring related educational resources. In other repositories, professional indexers perform the task of tagging educational resources.

Our approach to assigning tags presents some advantages over the "manual" generation: it is less time-consuming; it has not any problems with synonymy and polysemy; and it is very consistent—it does not depend on personal preferences when assigning tags.

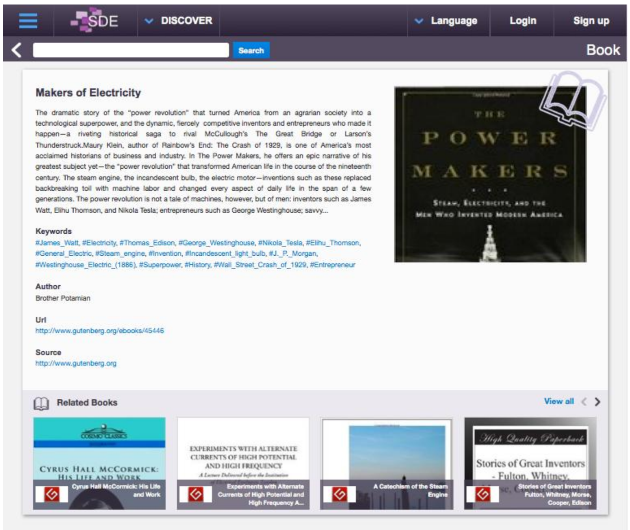

Image 2: Detail of an educational resource—a book.

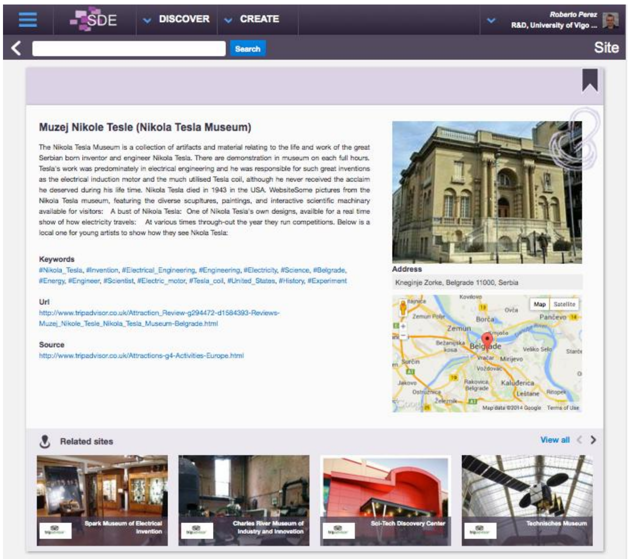

Image 3: Detail of the Nikola Tesla Museum in Belgrade, and related museums.

Related resources

In the detailed view of a particular resource, we can see how the system suggests to the user other resources that might be of interest, on the basis of the semantic relatedness to that resource.

In the first place, the system suggests resources from the same type of that currently being displayed. For instance, when the system is displaying the details of a particular book, the first row of related resources is composed of other books with a similar thematic. Immediately below, the system displays related resources from other categories—documentaries, lectures, etc. Thus, the user may click on any related resource and navigate to its detailed view, which in turn will display its own related resources. This procedure for discovering content is called exploratory search through the space of related resources.

4. SELECTING EDUCATIONAL RESOURCES

Our approach to exploratory search has to do with the idea that users interact with the SDE, navigating through the space of concepts, using the semantic annotations in educational resources for navigating through other concepts, and navigating towards the resources related to a given one. The final objective of that exploration is the gathering of educational resources that may be later combined in the didactic planning of a Future Classroom Scenario.

As a mechanism for gathering educational resources, we implemented the functionality of bookmarking them, in a similar way to that of a Web browser. Thus, from the page for visualising a resource, users can bookmark the resource that is being currently displayed. Besides, in the personal space of users, they can access to "My bookmarks", which is a page that displays all the resources they have bookmarked insofar, organised in accordance with their categories.

For each one of the categories the SDE shows a thumbnail with the title plus a representative picture of each bookmarked resource. In this screen, users can also un-bookmark resources. Following with our example of the Future Classroom Scenario entitled "Life and Works of Nikola Tesla", the figure shows some bookmarked educational resources, gathered in an exploratory search:

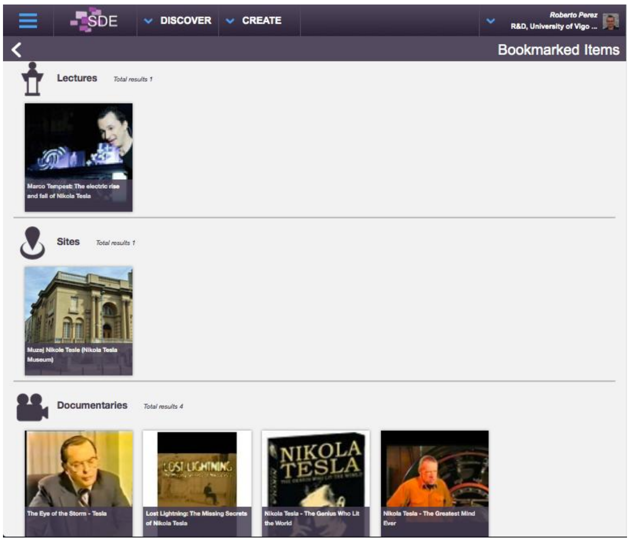

Image 4: Selected resources on Nikola Tesla.

5. COMBINING EDUCATIONAL RESOURCES

In the SDE, we integrated an editor devoted to the lightweight planning of Future Classroom Scenarios. The approach of that editor is combining resources and free text in the form of a narrative. In this way, a teacher may combine biographies, lectures, events, documentaries, and rest of elements, in a sort of "story".

Thus, the concept of narrative or "story" is central in this proposal. This is a key distinctive feature from other planning alternatives, which choose a more structured approach.

The bar at the bottom of the page allows for selecting the type of element that we want to incorporate into the narrative: free text, application, event, etc. We wanted the editor to be as easy-to-use as possible; hence, the interface works in a drag-and-drop way, enabling a convenient sorting of elements of the narrative.

Image 5shows a narrative with tree elements: free text, a biography, and a lecture. The user is dragging the second paragraph. In the bottom of the editor we can see the bar for adding new elements to the narrative.

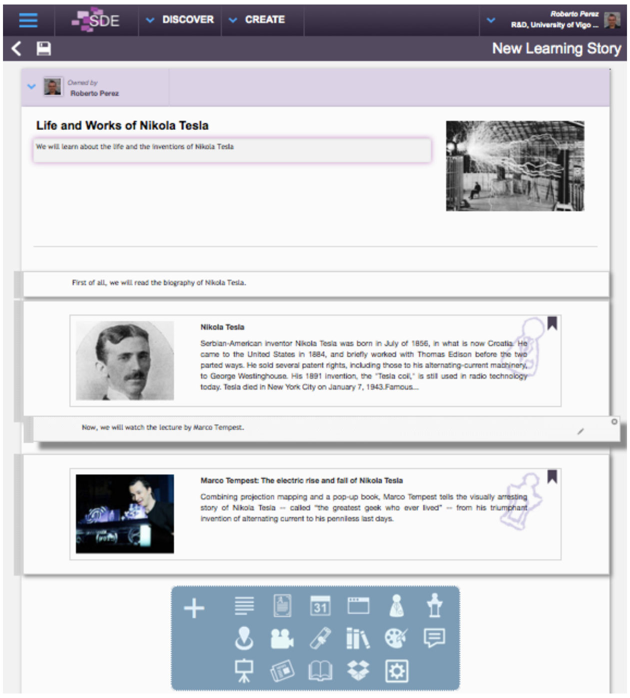

Image 5: Combining educational resources on Nikola Tesla in a Learning Story.

6. FIRST EVALUATION RESULTS

In order to design the search engine, we followed the problem-centred approach described by [11], and that is known as Design Science Research Methodology (DSRM). We think that DSRM is particularly well suited to address the evaluation of an artefact such as the SDE.

In order to evaluate the search engine, several workshops were conducted under the umbrella of the iTEC project. As DSRM proposes, every workshop allowed us to gather feedback for refining the design. The table shows data of those workshops. At the end of the iTEC project, an online survey was issued. The sample of the survey consisted on20 teachers. The online questionnaire served us to gather data that enabled a more formal evaluation.

The results gathered from the questionnaire are very positive, and they indicate teachers perceive that exploratory search very positively. The following images show the answers to the questions: "How do you evaluate the navigation through the space of topics?", "How do you evaluate the exploratory search through the keywords of particular resources?", "How do you evaluate the exploratory search through related resources?", "Are bookmarks useful?", and "Evaluate the usability of the tool for creating new Learning Stories".

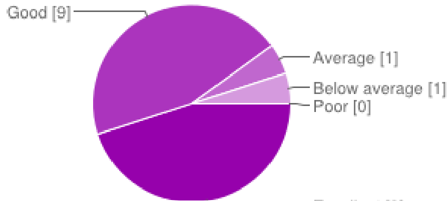

Image 6: How do you evaluate the navigation through the space of topics?

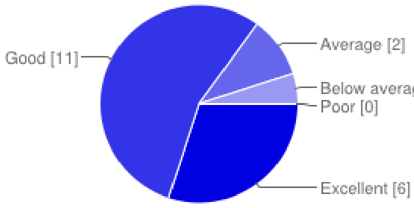

Image 7: How do you evaluate the exploratory search through the keywords of particular resources?

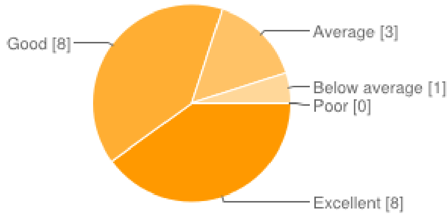

Image 8: How do you evaluate the exploratory search through related resources?

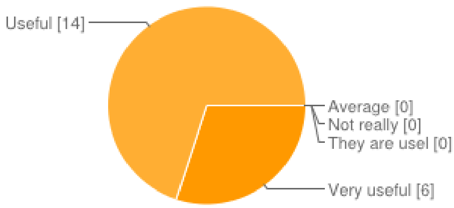

Image 9: Are bookmarks useful?

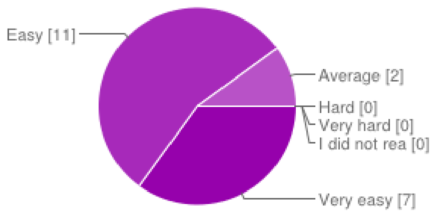

Image 10: Evaluate the usability of the tool for creating new Learning Stories.

7. CONCLUSION

In the first place, it is remarkable the great potential of the techniques for Exploratory Search that were outlined in this article, which are well suited for discovering educational resources that deal with particular concepts. The concept-based approach completely overcomes the problems of synonymy and polysemy, associated with traditional keyword-based searches.

It is worth noting that the foundations of Exploratory Search could serve as the basis for the implementation of information retrieval systems on top of existing repositories of educational resources, which could benefit enormously from all the possibilities that Exploratory Search offers.

Finally, we want to remark the usability of the application for supporting the full process of creating didactic plans: finding resources, selecting resources, and combining resources.

ACKNOWLEDGEMENTS

The work presented in this paper was partially supported by the European Commission's FP7 programme—project iTEC: innovative Technologies for an Engaging Classroom (Grant no. 257566); and the Spanish Ministry of Science and Innovation under grant "Methodologies, Architectures and Standards for adaptive and accessible e-learning (Adapt2Learn)" (TIN2010-21735-C02-01). The content of this paper is the sole responsibility of its authors and it does not represent the opinion of the European Commission, or the Spanish Ministry of Science and Innovation, which are not responsible of any use that might be made of the information contained herein.

LITERATURE

[1] L. Huang, "Concept-based text clustering," no. April, 2011.

[2] O. Egozi, S. Markovitch, and E. Gabrilovich, "Concept-based information retrieval using explicit semantic analysis," *ACM Trans. Inf. …*, vol. 0, no. 0, pp. 1–38, 2011.

[3] L. Reeve and H. Han, "Survey of semantic annotation platforms," *Proc. 2005 ACM Symp. Appl. …*, 2005.

[4] E. Gabrilovich and S. Markovitch, "Computing Semantic Relatedness Using Wikipedia-based Explicit Semantic Analysis.," *IJCAI*, pp. 1606–1611, 2007.

[5] D. Milne and I. H. Witten, "Learning to link with Wikipedia," in *Proceeding of the 17th ACM Conference on Information and Knowledge Management (CIKM '08)*, 2008, pp. 509–518.

[6] P. N. Mendes, M. Jakob, A. García-Silva, and C. Bizer, "DBpedia spotlight: shedding light on the web of documents," in *Proceedings of the 7th International Conference on Semantic Systems*, 2011, pp. 1–8.

[7] D. Milne and I. H. Witten, "An open-source toolkit for mining Wikipedia," *Artif. Intell.*, vol. 194, pp. 222–239, 2013.

[8] R. Mihalcea and A. Csomai, "Wikify!: linking documents to encyclopedic knowledge," in *Proceedings of the sixteenth ACM conference on Conference on information and knowledge management*, 2007, pp. 233–242.

[9] D. N. Milne, I. H. Witten, and D. M. Nichols, "A knowledge-based search engine powered by wikipedia," in *CIKM '07: Proceedings of the sixteenth ACM conference on Conference on information and knowledge management*, 2007, pp. 445–454.

[10] F. Boubekeur and W. Azzoug, "Concept-based indexing in text information retrieval," *Int. J. Comput. Sci. Inf. Technol.*, vol. 5, 2013.

[11] K. Peffers, T. Tuunanen, M. Rothenberger, and S. Chatterjee, "A design science research methodology for information systems research," *J. Manag. Inf. Syst.*, vol. 24, no. 3, pp. 45–77, 2007.