Categories of Research Methods and Types of Research Results Illustrated with a Continuous Project

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Keywords: Categories of Research Methods, Types of Project Results, Continuous Research Project in Enterprise Architecture.

Abstract: Research projects are often continuous, they are initiated by one researcher and continued by another. Each researcher needs to understand the continuous project and his part in it. This part we call a mini project. Explanation of research methods and projects results in literature does not help in understanding continuous research projects. Descriptions of research methods are often full of details and do not show relations between projects supported by different research methods. In this paper, we put all research methods into three categories and define two types of results. We suggest defining a mini project by a research method category and its result type. From such mini projects we build continuous projects. This way of structuring is illustrated with a continuous project investigating a view on changes of enterprise architecture. The relations of mini projects of different categories are generalized in a guidance for researchers, supervisors and reviewers.

1 INTRODUCTION

Each classification has its own purpose. The purpose of the classification proposed in this paper is facilitating researchers to build continuous research projects and involving researchers of different background to work in joint projects. Continuous research projects are often needed for gathering information from such complex research objects as enterprise architectures and information systems.

A modern tendency nowadays is to fuse research groups and combine researchers of different domains. In such groups with a mixed background, a classification of categories of research methods, preferred by different researchers, and relations of these methods is of vital importance.

It is also known that the international research projects usually combine different research types and domains. Researchers of different domains need to understand the methods and results of each other.

This paper aims at showing that a modern project is usually a composition of mini research projects. A mini project can be defined by its method category and its result type. Depending on the method category and the result type, each mini project stimulates mini projects of other categories.

The proposed classification of research projects is illustrated with a continuous research project in the area of enterprise architecture.

The proposed classification is generalised in a guiding model for building continuous projects.

The structure of the paper is the following.

Section 2 presents the categories of research methods and types of results from which we propose to build the complex and joint projects.

Section 3 describes a continuous research project investigating "A View on Changes of an Enterprise Architecture derived from two Enterprise Architectures". We apply our categories to describe this project as a composition of mini projects.

Section 4 is the discussion of the use of categories and result types to compose and decompose of continuous research projects. The related work is critically reviewed and shows the need of the categories in the choice of research methods in continuous research projects. The relations of different mini projects of different categories are generalized and presented in a guiding model for building continuous projects.

Section 5 contains conclusions about the presented position and possible future work.

Roubtsova, E.
Categories of Research Methods and Types of Research Results Illustrated with a Continuous Project.
DOI: 10.5220/0007747806340641
In *Proceedings of the 21st International Conference on Enterprise Information Systems (ICEIS 2019)*, pages 634-641
ISBN: 978-989-758-372-8

2 CATEGORIES OF RESEARCH METHODS AND RESULT TYPES

2.1 Categories of Research Methods

Let O be a research object (Figure 1). Some examples of research objects are: a business process, an enterprise architecture, behaviour of people, success of a business, inconsistencies in theory and practice, effects of new technologies on business and life.

Let R be a researcher, shown as a thinking person in Figure 1. We can assign a background attribute to each researcher: an enterprise architect, a software engineering researcher, a human communication researcher or a business researcher.

A research method category indicates the relation between a researcher and research object (R, O). All research methods can be classified into three categories (Figure 1):

1. "Borrow" the knowledge about the research object O from a source (book, article, human). The research object O is not changed.
2. "Observe" the information about the research object. The research object O is not changed.
3. "Intervene" in the research object. The research object O is changed. Only in this category, the researcher is associated with the research object as the research methods of this category create or transform the research object.

The first category, "Borrow", covers such research methods as different kinds of literature review and different sorts of interview. Using a literature review, the researcher borrows from a source. Organizing an interview, the researcher borrows from people.

The second category, "Observe", covers many methods of data collection with and without tools. A tool for observation may be a research object on its own.

The third category, "Intervene", includes a "bite" of the research object to cut it, to separate its parts and then synthesize. The intervention is the dominant research method category in design and modelling research.

2.2 Result Types

Any research method can result in one of the following results:

- an unobservable definition of the research object O, found or not found;
- an observable definition of the research object O;
  - an observable definition can be external, usually in the form of a list of properties or attributes;
  - an observable definition can be internal, in the form of a model or an algorithm for building the research Object O.

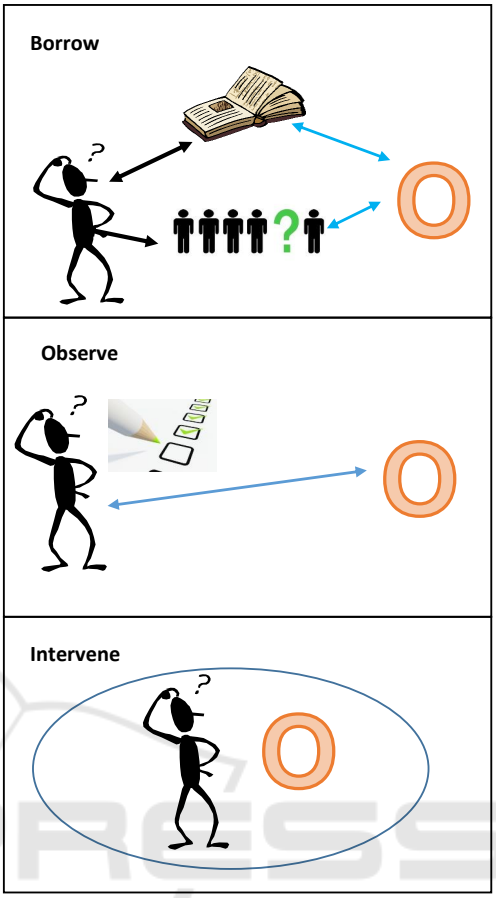

Figure 1: Categories of research methods (Roubtsova, 2015).

In the next sections, we apply the proposed categories of research methods and result types to categorize mini research projects of a continuous research project in the area of Enterprise Architecture and to propose a guidance for decision making during a continuous research project.

3 CONTINUOUS RESEARCH OF A VIEW ON CHANGES IN AN ENTERPRISE ARCHITECTURE

Once up on a time, a master student was sent by his company to a course on modeling of enterprise architecture in the ArchiMate modeling language (The

Open Group, 2017). During this course, he told to the supervisor of his master thesis that he found a topic for investigation.

It is always good to listen students. They often surprise supervisors. The student was asked if he already applied ArchiMate for a case. The student made a picture showing the key idea of any Best-Of-Breed enterprise architecture at the high level of abstraction. This was a good start. However, the source of motivation of his investigation was not found yet. Yes, he was able to visualize the new architecture, but what was the interest for the research community in this visualization?

Suddenly, the student burst out explaining that the current practice of drawing of two enterprise architectures As-Is and To-Be made it difficult to recognize the changes that should be implemented. He was convinced that another view was needed. At this point, the hypothesis about a new view on changes was clear, but both of us could not be precise about it yet.

We started the usual research routine to check and formalize an upcoming hypothesis.

3.1 Mini Projects 1 and 2: Attempts to Borrow from a Source

At this point, the research object was seen as "an architecture view on changes that shows what is replaced by what, what is expended by what". Yes, it was the first definition of the research object O.

Mini Project 1. A researcher may always start with a critical literature review, but its critical part does not mean criticizing, it means small (may be, mental) experiments trying to reproduce the results found in literature. A critical literature review belongs to the category (R,O) "Borrow" from a source. It could result in

- a "found an observable view on changes" or in
- an "unobservable view on changes, found or not found ", as the student expected.

We found a few papers and data sets that presented the practice of changes in Enterprise architecture. So, the examples of enterprise architecture in papers and tools have been studied. We made a series of attempts to repeat the results from the literature and find "what is replaced or extended by what".

The examples have shown that two architectures As-Is and To-Be are usually used to express changes. It was difficult to find "what is replaced or extended by what" (Bakelaar et al., 2016).

The role of the supervisor is to listen and "separate the wheat from the tares" and to help in making the next step. Our categories of research methods and results help the supervisor to find a moment to stop the ongoing mini project and to start the next mini project and change the method.

Mini Project 2. Here, the next mini project was to find out whether there was a principal possibility to express changes in a suitable, well specified Enterprise Modelling language.

Analysing the ArchiMate (The Open Group, 2017) language, we have found that it had at least ideas of a view on changes. Other EM languages, for example, the 4EM method (Sandkuhl et al., 2014), did not have such an idea. In particular, one concept of ArchiMate, called GAP, was found interesting.

A GAP in ArchiMate is defined as "a statement of difference between two plateaus", where "a plateau represents a relatively stable state of the architecture that exists during a limited period of time" (The Open Group, 2017). However, this concept does not define what architecture elements and relations belong to a GAP. GAP has no means to express "what is replaced or extended by what".

So, this mini project, of the category "Borrow " from a source, has resulted with an "unobservable definition of the research object O".

3.2 Mini Project 3 and 4: Design Means Intervene

Mini Project 3. At this point, it became clear that we might propose new relations to extend all Enterprise Modelling languages and define a new view on changes.

Mini project 3 was of the category "Intervene". The research object O was still a view on changes, but we needed to design it. The unobservable definition of a GAP from ArchiMate should have been transformed into an observable definition of a Gap-Of-Changes.

We defined the new view using the elements (boxes presented components of the Enterprise Architecture on different levels of abstraction) and relations of elements used in ArchiMate. We extended the set of relations with $\ll$ replaced-by$\gg$ and $\ll$extended-by$\gg$. A Gap-Of-Changes was defined as a tuple of sets of Obsolete objects, New objects, Changed objects, Obsolete relations, New relations, Replaced-by, Extended-By, and Border relations (Bakelaar et al., 2016).

Further, the business process architecture layer was excluded from the Gap-Of-Changes, because the semantics of elements and relations in the process was

known to be different from the semantics of the elements of the application and implementation layers.

It was possible to exclude from the view on changes all unchanged objects. However, some of them might have relations with the changed elements. As we were thinking about manual derivation of any view Gap-Of-Changes from an As-Is and a To-Be architectures, the inclusion of unchanged elements into the view was left to the architect to decide. So, a Gap-Of-Changes could contain the unchanged elements needed for positioning of changed and new elements.

Mini Project 4. An internal definition of a view Gap-Of-Changes should be accompanied with an process of its building from As-Is and a To-Be. This is an "Intervene" mini project, aimed to produce an instance of a new view on changes and describe the process of its derivation.

The student found a very actual case of replacement of an Enterprize Resource Planning (ERP) system with Best-of-Bread components. He presented a small subset of such a replacement (Bakelaar et al., 2016), where the old communication component via e-mail was replaced with new components supporting communication with customers and Business-to-Business. The changes were made within the application and implementation layers of the Enterprise Architecture, including the data storage.

Our student researcher described the steps of the derivation process of the view on changes and stated the need for process validation and the investigation of the usefulness of the designed view.

3.3 Case Studies as "Intervene" and "Borrow"

In order to validate the process of derivation of Gap-of-Changes and the usefulness of this new view, three mini research projects were organized as case studies. Each case study was fulfilled by a new research student.

The object of each case study was a Gap-Of-Change view derived from the As-Is and To-Be architectures of a real organization.

Each case study is a combination of two mini projects:

- The first mini project is of the category "Intervene". It is a design of the To-Be and sometimes the As-Is architecture (not every company has an up to date visualization of its As-Is architecture) and the derivation of the corresponding Gap-Of-Change view.
- The second mini project is of the category "Borrow". It contains a pair of interview workshops that starts with refreshing the semantics of ArchiMate.
  1. In the first interview workshop, a group of participants gets an As-Is and a To-Be. The group is asked to found and count obsolete, new, changed objects, and obsolete and new relations.
  2. In the second interview workshop, the same group of participants, apart from the As-Is and To-Be, gets also the corresponding Gap-Of-Changes view. The participants are asked to found and count obsolete, new, changed objects and obsolete and new relations.
     The new view Gap-Of-Changes is in the worse position, in comparison with the As-Is and To-Be, which are learned by the participants during the first interview workshop. However, if the participants recognize more elements in the second workshop, then the new view Gap-Of-Changes has its added value.

Let us describe all case studies in more detail.

3.3.1 Mini Projects 5 and 6. High School Case

Mini Project 5. One case was carried out in a high school.

In the As-Is situation, the high school makes plans for five years and for one year using Excel. Using these plans, the high school makes schedules in a scheduling system. The deviation of the terminology used for planning and scheduling in two different applications makes scheduling error prone.

The analysis of this case shows that the high school can improve consistency of schedules and plans by using one plan-scheduling application with the shared database instead of using a spreadsheet application for planning and the old application for scheduling. One storage of the information for planning and scheduling leaves less room for mistakes as the instances of concepts are chosen from lists.

The proposed changes in the application and technical components layers support the goal of consistency between plans and schedules (Bos, 2018). This was the advice to the High School given on the basis of enterprise modelling.

The As-Is and To-Be models were depicted and the Gap-Of-Changes was manually derived.

Mini Project 6. The interview workshops were organized to check if the users recognize changes.

Tables 1 and 2 show the numbers of changed elements and their recognizing by the participants $P1, ..., P5$ of the workshops. First, they observed only

the As-Is and To-Be (Table 1) and, second, they observed the As-Is, To-Be and Gap-Of-Changes (Table 2).

Table 1: All Changes in the High School case and Changes found by the workshop participants P1,..., P5 observing the As-Is and To-Be.

Change	All	P1	P2	P3	P4	P5
Obsolete object	3	0	2	1	0	1
New object	1	1	1	0	0	1
Changed object	1	0	1	0	0	0
Obsolete relation	5	0	3	1	1	3
New relation	3	0	3	1	0	1

Table 2: All Changes in the High School case and the Changes found by the workshop participants P1,..., P5 observing the As-Is, To-Be and Gap-Of-Changes.

Change	All	P1	P2	P3	P4	P5
Obsolete object	3	2	1	0	1	2
New object	1	0	1	0	0	1
Changed object	1	0	1	1	1	1
Obsolete relation	5	0	3	1	1	3
New relation	3	0	1	1	0	1

The tables show that slightly more changes were recognized in the second workshop, when the participants observed the As-Is, To-Be and Gap-of-Changes, than when they observed only the As-Is and To-Be. However, the difference was not sufficient to see an added value of the Gap-of-Changes view.

3.3.2 Mini Projects 7 and 8. Radiology Department in a Hospital

Another case study was in the Radiology Department of a Hospital.

Mini Project 7. The applications for reading and describing images *ViewPro-X* and *G2Speech* were being replaced with applications *Zillion Read* and *Zillion Dictate*. Another change concerned the connection of the *Patient Data* of the Hospital with the University Medical Center. The As-Is and To-Be architectures were visualised and the Gap-Of-Changes view were derived. (Haddouchi, 2018).

Mini Project 8. The interview workshops were organized for three participants $P1$,$P2$ and $P3$. Table 3 shows that, with the observation of the As-Is and To-Be, the values of counters of the recognized obsolete, new, changes objects were higher than the counters of relations. The participants mentioned that they did see changed objects, but did not pay attention to relations.

Tables 3 and 4 show, that with the observation of the As-Is and To-Be and Gap-of-Changes, the values of counters were higher, but not sufficient to see an added value of the Gap-of-Changes view.

Table 3: All Changes in the Radiology Department case and the Changes recognized by participants P1,P2,P3 by observing As-Is and To-Be.

Change	All	P1	P2	P3
Obsolete object	16	10	4	8
New object	16	10	6	10
hanged object	0	0	0	0
Obsolete relation	5	0	2	0
New relation	13	2	4	5
Border object	0	0	0	0

Table 4: All Changes in the Radiology Department case and the Changes recognized by participants P1,P2,P3 by observing As-Is, To-Be and Gap-Of-Changes.

Change	All	P1	P2	P3
Obsolete object	16	13	13	7
New object	16	14	13	7
hanged object	0	0	0	0
Obsolete relation	5	2	4	5
New relation	13	9	5	9
Border object	0	0	0	0

3.3.3 Mini Projects 9 and 10. Legacy System to ERP Case

The most interesting case was the replacement of a legacy system of a food supplier with an ERP with some Best of Breed components.

The changes were so numerous, that it was found error prone to derive the Gap-Of-Changes and count changes manually. Afterwards, we found 25 obsolete, 13 new, 13 changed objects and 41 changed relations.

Mini Project 9. A new mini research project was set on how to automatically derive the lists of obsolete, new, changed objects, and obsolete and new relations from an As-Is and a To-Be and count changes.

This mini project is of category “Intervene”. It is aimed to revise the definition of a Gap-Of-Changes. To make the automated derivation possible, the border elements and border relations were precisely defined in the Gap-Of-Changes (Dijkstra and Roubtsova, 2019). An automation tool (Dijkstra, 2018a) was designed. The tool produced the lists of obsolete, new, changed, border objects, and obsolete, new and border relations.

The As-Is and To-Be architectures were visualised for this case (Dijkstra, 2018b). The lists of changed elements were derived by the automation tool and the Gap-of-Changes was visualised using these lists.

Mini Project 10. The workshops for testing of usefulness of the view on a Gap-of-Changes were organized. Table 5 shows the numbers of all changes and the changes counted by five participants observing the As-Is and To-Be. The visual form of Gap-of-Changes was so confusing that the counters had even lower numbers than in Table 5.

Table 5: All Changes in the case "Legacy to ERP " and Changes found by the workshop participants P1,...,P5 observing the As-Is and To-Be without tool.

Change	All	P1	P2	P3	P4	P5
Obsolete object	25	6	7	6	7	11
New object	13	2	4	2	4	6
Changed object	13	0	0	0	1	0
Obsolete relation	41	1	0	1	0	0
New relation	26	0	0	0	0	0
Border object	6	0	0	0	1	0

After this workshop, the participants were presented with the lists of changed elements, i.e. the Gap-Of-Changes in the form of lists. They were found useful both by the enterprise architects and by managers.

- The enterprise architects mentioned that the lists allowed them to check the consistency of As-Is and To-Be architectures.
- The managers mentioned that the lists could be used for planing of the implementation of changes.

As we see, this case initiated the new "Intervene" project to automatically generate the research object Gap-Of-Changes resulted in user satisfaction.

The test cases may be continued. The automated tool may become a research object for a new continuous research project.

4 DISCUSSION AND RELATED WORK

4.1 Categories and Results to Guide Continuous Projects

We have shown how the categories of research methods and types of results can be used to define mini research projects. However, there is another added value of categories and types. They can be also used to guide a continuous research project.

Figure 2 shows a guiding model for a continuous research projects built from mini projects.

- A result "unobservable definition of the research object O, found or not found" may be followed with another "Borrow" mini project, but often demands a follow-up "Intervene" mini-project as an attempt to built a research object definition or an example, to make it observable.
- A result "observable definition of the research object O" can be "external", i.e. presenting the object via its properties. This result can be validated in a next "Observe" or "Borrow" mini project.
- An "observable" definition can be "internal", i.e. presenting the object structure or an algorithm for its creating. This result may demand a combination of the "Intervene" and "Observe" mini projects, known as a case study.

In the continuous research project presented in this paper, the research object of all mini projects was a view on a changes of enterprise architecture.

The results of the first two "Borrow" projects (critical literature reviews in different sources) were of type "not found any view on changes in the enterprise architecture languages".

These 'Borrow" projects initiated two "intervene" projects to design a view on changes in the enterprise architecture language ArchiMate and the process of its construction. The results were observable internal definitions of (1) a view on changes and (2) a process of derivation of such a view.

Such results initiated the case studies for validation both the definition of the view and the process of its derivation. Each case study included an "Intervene" mini project to build a As-Is, To-Be and Gap-Of-Changes for a given company and a "Borrow" mini project to identify, how the Gap-Of-Changes helps users to recognize the changes.

Our two first case studies had the observable view on changes. The third case was too large to be observable and it stimulated another "Intervene" project to build a tool for automatic derivation of the view to make it observable.

All case studies were followed with the "Borrow" projects (in from of workshops) where the changes were counted by the participants. The case studies have shown that it was difficult for users to recognize all changes even with the new view Gap-of-Changes. The automatic derivation of lists of changes was found useful.

The testing of the tool for automatic derivation of the Gap-of-Changes may initiate new mini projects.

4.2 What Are the Advantages of Categories of Research Methods and Types of Results?

The categories can help junior researchers to understand their research direction and help to choose research methods. The categories may be clear for the experienced researchers, but should be taught to the

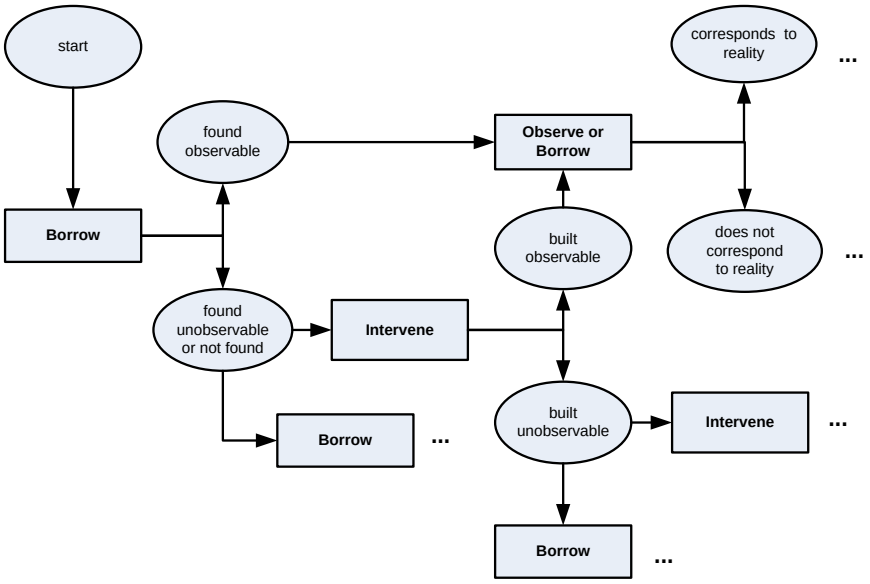

Figure 2: Building a research project from mini projects of different categories.

junior researchers. The author have seen this by observing multiple reads and downloads of the presentation on this topic on the Research Gate (Roubtsova, 2015). The junior researchers go deeply into the literature on research methods, where the research methods are thoroughly explained and described, for example in (Berndtsson et al., 2007; Saunders et al., 2009). However, the literature describes a huge amount of research methods and each research method is presented in detail without establishing the fact that results of one method can stimulate research with other methods. Our categories can guide the choice of a suitable method by restricting a subset of methods for selection.

Proposed categories provide more flexibility in the definition of a project success. In the design science literature (Hevner and Chatterjee, 2010), we can find a guideline for the design research projects. Three steps (Hevner, 2007) are demanded in any design research project to consider it successful: requirements, design and rigor. The main point of the authors is that a design research cannot be seen as successful without the rigor step at the end of each design project to test the designed artifact. In the view of mini projects, a research project without a rigor step can be seen as successful, if a designer has proven some properties of the research object mathematically or guarantied them technically. The research project in this case is successful, but the validation projects may be continued for the rigorous and, often, the object lifetime long validation. The research object can be put for observation and testing for everyone.

The supervisors and reviewers of continuous research projects may benefit if the project they supervise or assess are designed as mini projects of our categories. Thinking in categories helps a supervisor to understand in advance what to expect after implementation of the chosen method and make decisions for the next mini projects. Reviewers of research reports can easier reproduce research results of mini projects if necessary. The categories and types may help in assessment. Even if the details of the research method are difficult to understand, its application still can be assessed if the category of the method and the type of its result are clear.

5 CONCLUSION AND FUTURE WORK

The first contribution of this work is a definition of a set of three categories of research methods and two types of their possible results used to define mini-research projects in a continuous research project.

The second contribution of this work is a guidance for the choice of categories of mini projects depending on the result types of previous mini projects. The guidance is presented in Figure 2. The use of categories and the guidance has been illustrated with a real continuous research project on a view on changes in Enterprise architecture (Bakelaar et al., 2016; Bos, 2018; Haddouchi, 2018; Dijkstra and Roubtsova, 2019). This continuous project was built from mini projects of different categories.

In the future, the author is going to present other

continuous projects built from such mini projects: projects for developing of KPIs, projects on using process mining for process audit, projects on design and measurement of service level agreements. It is useful to describe the research methods in context of many continuous research projects to share the process of gathering research results and to clarify the advantages of research explanation in terms of categories of research methods and project results.

All the continuous projects supervised by the author are from such areas as Information Systems Analysis and Specification and Enterprise Architecture. That is why, the author can claim the use of proposed categories in these areas. We argue that the categories are applicable for research projects in other domains as well, however, the application of categories in continuous projects in other domains need to be tested.

The categories of mini research projects and types of their results may become a skeleton of a future tool for continuous research project management. This tool can help to clarify methodology, that is, it can help in research and education. The industrial project management tools are not always applicable in education as they often focus on project constraints instead of research methods and relations of their results. A continuous research project management tool built on our categories may guide a continuous project in its choice of mini projects, organize the data, results and methods associated with each mini project. Creating a data storage and classification of the methods and results will facilitate the reviews of each mini project and increase the level of responsibility of researchers for the used methods and claimed results.

ACKNOWLEDGEMENTS

The author thanks the graduate students of the Open University of the Netherlands: Robert Bakelaar, Martijn Bos, El Makki Haddouchi and Richard Dijkstra, for their enthusiasm and work on mini research projects in the continuous project on studying a view on changes in Enterprise Architectures. Many thanks to Prof. Stef Joosten for fruitful discussion of research methods.

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