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Enterprise Architecture Oriented Requirements Engineering for Open Data Usage in Schools

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Abstract. Open Data has been considered as a key to scientific innovations. These openly licensed data-sets can be accessed, used, rebuild, and shared by anyone and anywhere. Mostly, Open Data is discussed in relation to its production, storage, licensing and accessibility, but less often - in relation to its practical subsequent uses, e.g. as an educational resource. In general, Open Data can be used as an open educational resource to develop transversal skills among school students. This paper presents an Enterprise Architecture Oriented Requirements Engineering (EAORE) approach for Open Data usage as an educational resource in Danish public schools. The aim of this research work is to identify requirements of Danish public schools for the development of an Open Data interface. The EAORE approach represents how Enterprise Architecture (EA) models guide overall Requirements Engineering (RE) process for Open Data usage in Danish public schools.

Keywords: Enterprise architecture, Requirements engineering, Open Data, Open Data interface, Educational resource.

1 Introduction

Open Data is openly available data-sets permitting citizens to freely use, modify, and share them for any purpose [2]. Open Data is data-sets, that are open to everyone, i.e. citizens, businesses, non-profits, public administrations, and technologists. It is a source that promotes democracy, transparency, civic engagement, efficient public services, and economic growth. Open Data opportunities and benefits could increase significantly, if citizens were able to use that data effectively and efficiently [5, 6]. Hence, citizens' active engagement is vital to harness the power of Open Data. However, in general, Open Data debates and research focus more on the technical side, e.g. collection, storage, availability, licensing and have overlooked the public issues and its consequent uses [3, 4], e.g. which data-sets public needs, how Open Data can be used as an educational resource, and how citizens can be engaged in exploiting available Open Data?

In order to equip the future generation with future essential learning skills, it is important to engage the younger generation of school students with Open Data. Open Data can act as a key, to develop digital and data literacy skills, enhance critical thinking, and civic awareness among higher education students [10]. Hence, Open Data is not only a potential resource of opportunities for public (e.g. to improve public services, to bring transparency etc.); it could also act as 21st century raw material to develop digital and data skills among public school students, and as a source to inform them about their communities. Yet, the educational use of these openly available data-sets are not fully exploited, specifically in the schools, e.g. to facilitate teaching activities using Open Data as part of different subjects.

Many open data-sets are available on Open Data portals, that could be used as part of basic teaching materials. Public schools could experiment with these openly available data-sets not just to grow public engagement but to develop digital and data skills, and to foster civic awareness among younger students by providing useful local information through Open Data. For instance, pollution level, noise level and water quality data-sets can provide the current situation of local areas as part of chemistry subject. Students can further discuss why the levels are high or low, and how they could improve the situation [7]. Open data-sets can also be used as educational resources, to support different other teaching subjects, and permit students to work with the actual data-sets and to develop new learning skills [11]. Hence, many countries start taking initiatives, and launch different projects to introduce the possible opportunities of Open Data [34] to the younger generation of students. The research work described in this paper is affiliated to the part of the Copenhagen Community Drive project [31] with particular focus on the city's many types of data and how to put them into use especially in an educational context. The project focuses on how existing Open Data could facilitate the educational process in Danish public schools and how we can integrate technology in schools in a way that benefits students' digital and learning skills.

In order to facilitate educational activities using Open Data, appropriate open data-sets, e.g. environmental, geographical and traffic data-sets should be visualized in simple graphs, e.g. bar, pie or line [30]. However, the use of data also requires a lot of effort by the teachers and they may need data analytics skills to fragment the bigger data-sets into smaller data-sets and make visualizations. To stimulate the use of Open Data in Danish public schools, our idea is to integrate an Open Data interface in schools, where teachers and students can relate their subjects to actual information of their local areas, and compare the data with other communities in the form of simple visualizations. However, for the development of such an interface, it is important to identify teachers and students requirements. To the best of our knowledge, there exist no guidelines for the RE process for Open Data usage in schools as an educational resource. This paper attempts to make a first step towards defining a best practice for such situations using Enterprise Architecture Oriented Requirements Engineering (EAORE). The characteristics and challenges of our research question *"How EA guides*

RE process to derive teachers/students' needs and requirements to stimulate the use of Open Data as an educational resource in Danish public schools?" have formed the basis for the development of Enterprise Architecture (EA) models using EAORE approach. We believe that the obtained results are sufficiently general and might be interesting for other researchers working in the domain of Open Data applications. We are aiming to develop EA models using EAORE, which helps to elicit requirements for the successful development of Open Data interface for schools. The interface could enable teachers to relate their subjects with the actual information, e.g. pollution level, noise level or traffic congestion near the schools. We integrate RE and architecture design to investigate the problem, specify solutions, and validate them for the development of Open Data interface that allows teachers to use open Data as an educational resource at public schools.

The structure of this paper is as follows: In Section 2, we discuss the research method and related work, where we demonstrate the theoretical boundaries of RE and EA. In Section 3, we provide a frame for EAORE in the context of Open Data usage in schools; and in Section 4, we provide the conclusions and point to our future work plans.

2 Research Methods and Related Work

The research methods applied in this work consists of the following steps:

1. Analyze open data-sets of target domains.
2. Identify Open Data impact domains that may facilitate teaching.
3. Analyze available data visualization tools.
4. Survey Danish schools to learn teachers and students perspective on Open Data.
5. Envision a possible solution for Open Data usage in schools.
6. Propose an approach for the identification of requirements for the envisioned solution.

Denmark is famous for its Open Data initiatives, and has a national portal [3] for Open Data where cities, organizations, and researchers publish useful data for public. This data is used to develop different mobile applications and improve public services to bring benefit to the citizens of Denmark. In order to use open data-sets as educational resources in the Danish public schools, we carefully *analyzed open data-sets of Copenhagen city*, the capital of Denmark that has more than 290 open data-sets from different sources, accessible from the national Open Data portal of Denmark. These data-sets are available in different data types e.g. graphical data, statistical data and live data and in different data formats, e.g. CSV, PDF, JSON etc.

We *identified four impact domains (educational domains), i.e. environment, demographic, geographical and statistical data domains* that can easily facilitate

[3] http://www.opendata.dk/

teaching being a part of basic school subjects, (science, social science, geography and mathematics), in public schools. Some *open source data visualization tools were also analyzed* for their possible adoption to visualize Open Data. We also *surveyed ten Danish public schools* to understand teacher and student perspectives in Open Data usage in schools. All this work is discussed in [7]. Teachers were very positive in facilitating teaching with actual information, but they required ready to use data-sets and visualizations as part of teaching assignments. In addition, it was mentioned that the available open source tools for visualization are not in Danish, which was also considered a hurdle for the presentation of Open Data at school level in Denmark. Teachers requested an overview of what data-sets are available; and pointed to the fact that it requires both time and skills of teachers to present the right information to the students. Hence, development of an *Open Data interface* that enables students and teachers to select data-sets within educational themes, visualize them in the form of simple graphs, compare with other areas, and design activities to explore more data as part of respective subjects, *could solve above-discoursed issues*.

For the development of the Open Data interface for schools and to identify teacher and student requirements, we use RE, which is a process to investigate, define, document and maintain the requirements for the best desired solution. RE is not principally about just documenting requirements; instead, it focuses on understanding a business problem, and providing a solution for it [17, 18]. RE discipline has expanded over the last decade, and the process includes not only traditional techniques such as interviews, surveys and workshops [13] or viewpoint oriented RE [12], but has also steered several new techniques and models, e.g. GBRAM [14], i* [15], and KAOS [16]. There can be two different views on RE [19, 20], problem-oriented and solution oriented RE. Problem-oriented RE, focuses more on investigating and documenting a problem domain. The requirements engineer identifies the different factors (reasons) for the problem, the relations between these factors, why this is seen as problem, and who experience these problems. Goal Oriented RE (GORE) [21] is a very popular and widely used technique within problem-oriented RE. Goals are considered as high-level objectives of the system, business or organization that identify the reasons for the development of a system, and help to make decisions at different levels within an enterprise. Related work [22] gives a general description of the GORE, where as GBRAM and KAOS use the GORE techniques. Solution-oriented RE, on the other hand, uses the traditional techniques for software engineering, i.e. object-oriented analysis [23] and structured analysis [24]. The requirements specification for a solution represents the system from the software engineers perspective [25], e.g. system specification, system functions, quality attributes of these functions; and defines the alternatives for the best solution of the problem. Hence, the generic RE process consists of the following functions:

- Requirements Elicitation
- Requirements Analysis
- Requirements Specification
- Requirements Validation

Within, the RE domain, research is made in almost every field of business such as transport, education, health-care, etc., but no work is done within the development of requirements models for Open Data usage in schools.

We use RE with EA [26, 27]. EA can have a significant impact on the requirements engineering process [8]. EA is the complete, consistent and coherent set of methods, rules, models and tools, which guide the design, migration, implementation and governance of business processes, organizational structures, information systems and the technical infrastructure of an organization according to a vision [9, 28]. EA is the practice of analyzing, designing, planning and implementing enterprise analysis, to successfully execute on business strategies.

In our study, to derive the enterprise architecture models, the requirements were identified through interviews with Danish public school teachers, pilot tests and observations with students. Using EAORE, we explore and investigate requirements of Open Data interface for schools. For the representation of EA issues we use a selected set of elements of EA representation language ArchiMate [32] shown in Figure 1. Whereas for modelling, we used the Archi modelling toolkit [33]. To design the EA models in EAORE approach, we used four-layer

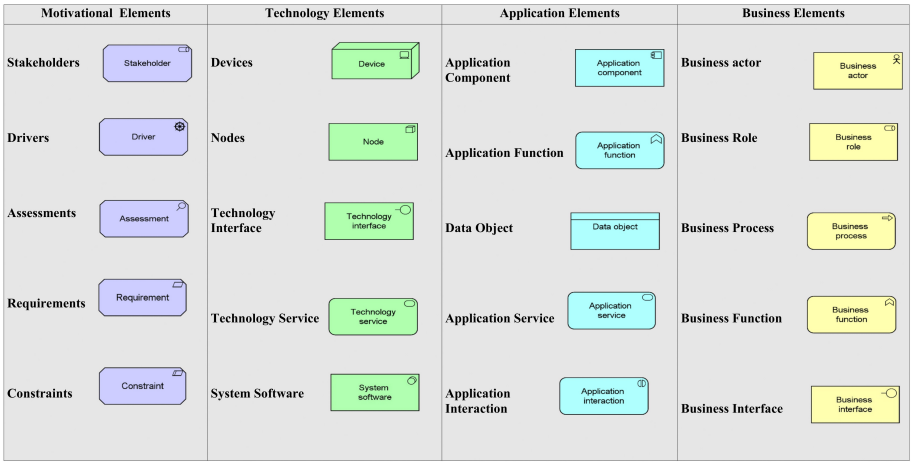

Fig. 1. Selected set of elements from ArchiMate

enterprise architecture frame as shown in Figure 2. Models are discussed in the next section. The developed frame is based on the above mentioned five steps of research method.

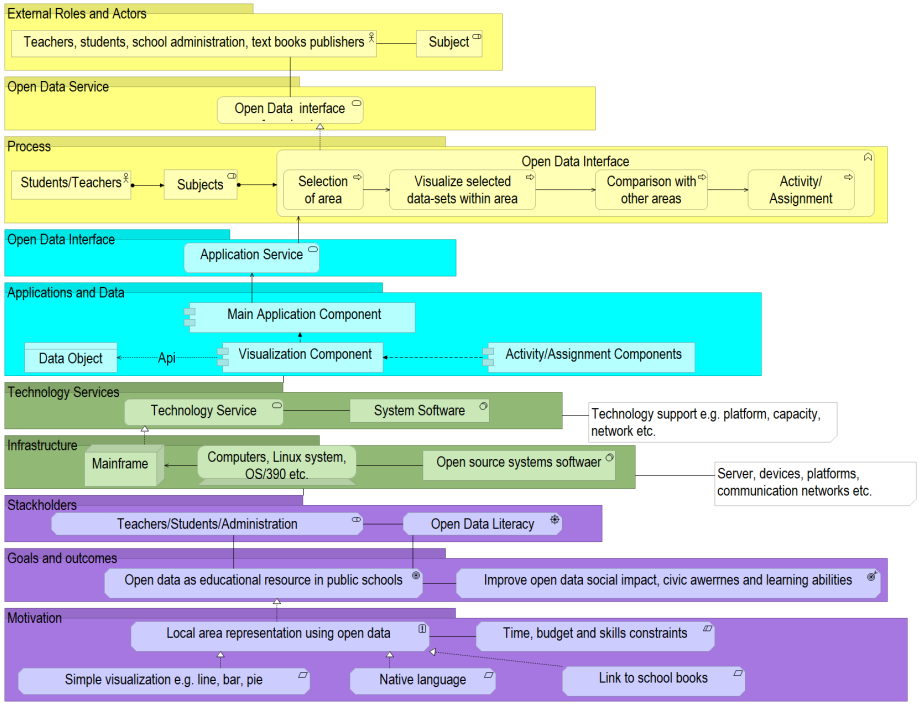

Fig. 2. Layered view of EA for open data usage in schools.

3 Enterprise Architecture Models in RE for Open Data Usage in Schools

Using EAORE, we have developed a four-layer EA frame using ArchiMate language as shown in Figure 2. Our EA frame for open data usage in schools, represents motivational layers, technology layer, application layer and business layer. Here the sets of (related) EA element types serve as a frame of reference, which guides RE in each layer. We investigate requirements in each layer with respect to different possible aspects shown in Figure 2. This layered view enabled us to illustrate the motivation for the interface, possible concerns and assessments, technology requirements, and the usage of applications in business processes and services they provide.

In the remainder of this Section, we will discuss possible requirements, needs and goals for each layer shown in Figure 2.

3.1 Motivation Layer

On the motivational layer, we have explored the stakeholders, their needs, concerns and assessments, and how they interact with the system (Open Data interface), what are the motivational aspects, (e.g. why teachers use Open Data),

and domain knowledge. The resulting model is shown in Figure 3.

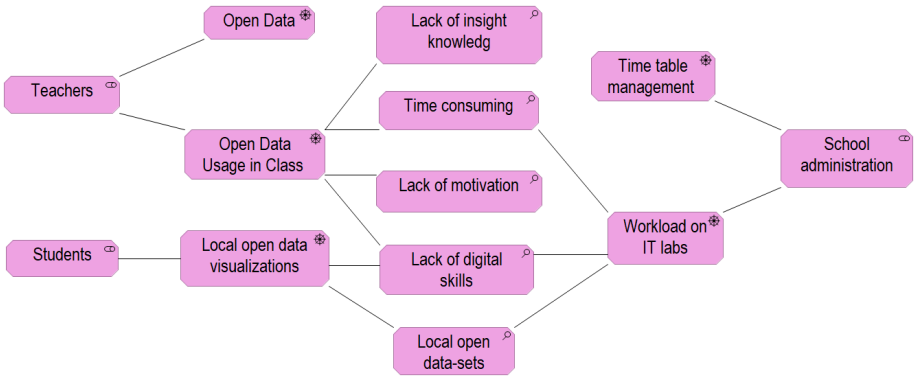

Fig. 3. Stakeholder, concerns and assessments.

Figure 4 represents the RE issues for the above mentioned needs and concerns.

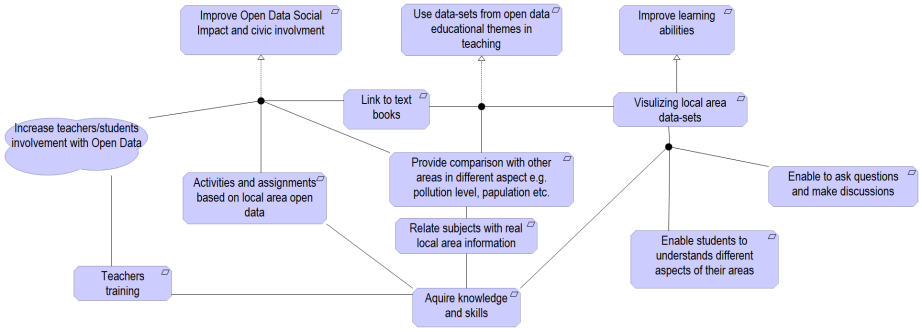

Fig. 4. Motivational level model.

In our case, we have identified four main stakeholders, namely, teachers, students and school administration (as internal stakeholders), and textbooks publishers as external stakeholders. Teachers are concerned with different data types, their graphs, cleaning of data-sets and transformations of data into other formats. Students need simple interactive graphs in their own native language. Teachers are reluctant to spend long time on data-sets searching. These identified concerns from the students and teachers, can lead to assessments. For instance, there exist many open data-sets with useful information, which are not being exploited. These data-sets can easily be used as open educational resources that can relate actual information to the study subjects to develop learning skills discussed in

previous sections. This would lead to the high level goal, "increase Open Data social impact and youth engagement with Open Data". Teachers and students are not able to work directly with Open Data as they need simple presentations of open data-sets in their own native language. This can be a problem, as teachers are hesitant to spend long time in identifying and visualizing the data-sets; and the available open source software for visualization is not in their native language. Through goal refinement, we reached the goals that we want to introduce an Open Data interface that allows students and teachers, to relate to their subjects with actual information using Open Data as an educational resource and to improve civic awareness and youth engagement with Open Data.

3.2 Technology layer

On this layer, we will explore what technology requirements are seen from the user and system perspectives. For instance, it is important that students and teachers have easy access to computer labs, internet, etc. For open data interface, open data-sets need to be divided further into smaller data-sets, containing the local area information. These data-sets are in different formats, e.g. CSV files, PDF files or other formats. A data management interface is required, to store these data-sets before visualizing. Open source operating systems and visualization software are required to visualize the local open data-sets. Figure 5 represents a technology layer model for open data usage in schools.

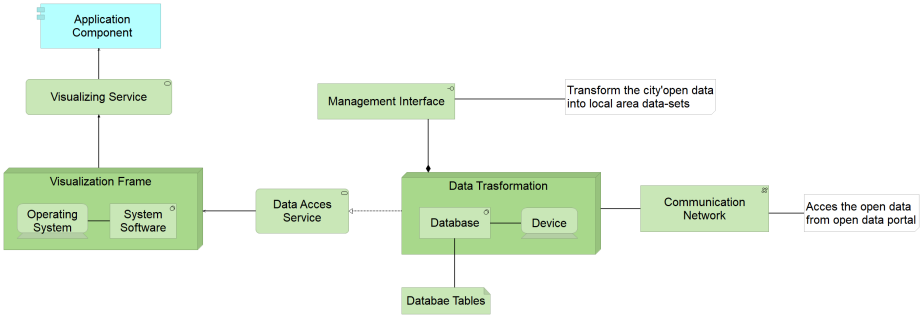

Fig. 5. Technology layer requirements model.

3.3 Application Layer

Figure 6 represents an application layer EA model for open data usage in schools. The application layer focuses more on application components, e.g. application specifications. This includes language, appearance, and being ease of use. The RE for this layer leads us to the development of one main component with navigation to three sub-components, i.e., data object, visualization component,

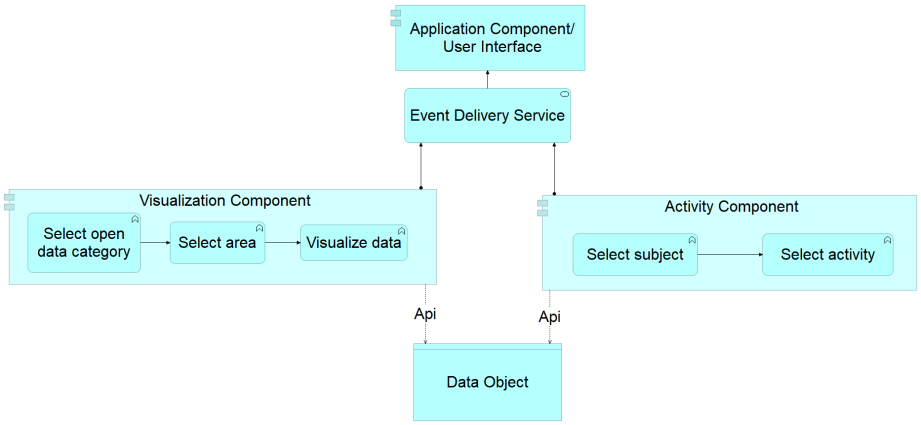

Fig. 6. Application view.

and activity component. Teachers need local area open data-sets in the form of simple visualizations, (line, pie, bar), in native (Danish) language, to relate their subjects with actual information. The application should be easy to use without any programming expertise, and with explained features.

3.4 Business Layer

The business layer leads towards the solution, i.e. an Open Data interface for the schools that enables teachers and students to take benefit from the data-sets. Figure 7 represents a usage view (model) for Open Data interface and Figure 8 represents business model for Open Data interface. In the business layer,

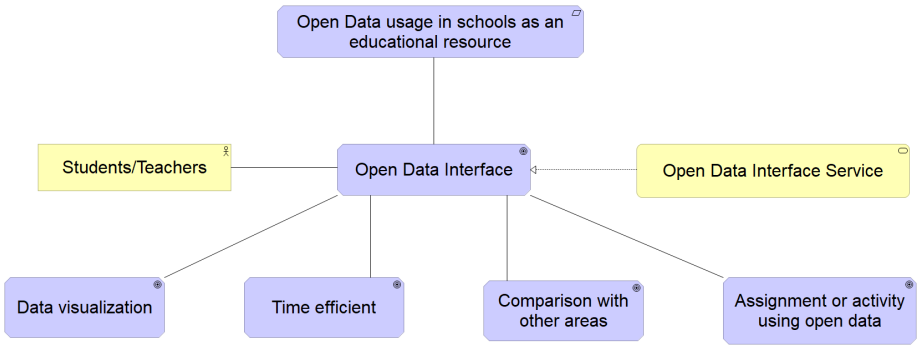

Fig. 7. Open Data Interface for open data Usage in schools.

textbook publishers are identified as external actors. They will play a central

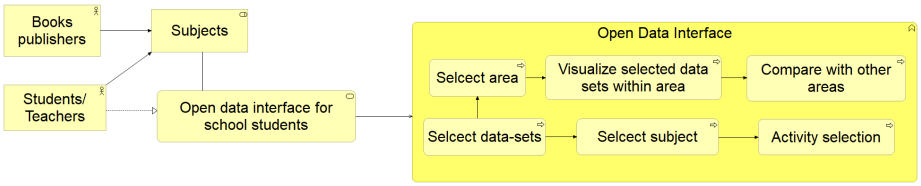

Fig. 8. Open Data Interface for open data Usage in schools.

role for the active use of this interface; by linking different subjects themes with Open Data interface for activities and explanations, e.g., in geographic subjects, they can link the interface for the presentation of respective local areas; or in science class, real local examples could provide information about pollution, noise or other environmental conditions. Such subjects as mathematics, science, geography and social science act as business roles, as these subjects can use Open Data for visual presentation of local areas aspects, to facilitate educational activities at school level.

3.5 Evaluation

In the above sub-sections, we have presented models based on EAORE approach for Open Data usage in schools. We have discussed the four layers, which form the base for our frame, and identified requirements in different aspects within these layers. Our EAORE approach for Open Data usage in schools is flexible and could be used by the neighboring countries to extend the potentials of Open Data at school level as an educational resource. Using EAORE, we cover motivational, application, technical and business aspects that enables us to make a transparent alignment between all these aspects. Using this approach, we derive systematic requirements at different layers that are aligned with each other in the form of models. These models will help us to compare how the need for Open Data usage will be met in an efficient, sustainable, and adaptable manner. Using EAORE approach, we can easily trace and change requirements at different stages of development of Open Data interface. Using this approach, we can also save time, e.g. we can identify requirements at different layers and change or validate them easily at any level using less time to compare to descriptions in text documents. The approach is easy to adopt and in future when we extended our research work (having more cases), we will also envision a requirements management system based on this approach. Currently this paper represents only a case specific model; we will elaborate EA models and develop analysis mechanism for more formal EA analysis in future work. It has to be noted that there are many relationships between elements of different layers of the frame. However, we showed only some of them in order to keep the discussion as simple as possible.

4 Concluding Remarks and Future Work

Open Data is a valuable resource with potential opportunities for both governments and public. This data can be used as a raw material to develop 21st century learning skills. These data-sets can be used as an educational resource to support teaching and learning activities as part of teaching subjects, e.g. mathematics, science, and geography. Teachers can relate their subject with Open Data in the form of simple graphs. In this paper, we investigated the teacher and student needs and requirements to stimulate the use of Open Data as an educational resource in Danish public schools. We used the EAORE approach and developed *EA oriented RE for Open Data usage in Schools*. The use of EA models helped to identify the requirements regarding different aspects i.e. motivational, technology, application and solution aspects. Our EAORE approach has a number of potential advantages, e.g. time saving, easiness of traceability and flexibility of modeling as discussed in Section 3.

In the future, we will elaborate this approach after having more cases and use it for requirements management system development. To validate the solution i.e. Open Data interface, we will first develop prototypes to test different parts of the Open Data interface in schools. This phase will help to explore and identify new problems, based on the proposed solutions. Based on these new problems, revised prototypes will lead us towards the final development of the interface. The interface will not only provide interesting information about local areas, but will also help to develop learning and digital skills, and bring more awareness, among the younger generation of school students about their communities and cities.

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