Reference Model in Design Science Research to Gather and Model Information

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Reference Model in Design Science Research to Gather and Model Information

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ABSTRACT
Design science research, at its current stage, does not offer consistent and detailed phases to guide researchers to manage information systems projects. In this paper we introduce a reference model that covers its phase of creating artefacts. This model serves as a base to gather relevant information in producing solutions to business’ problems in design science context. One aspect of the model is the capability to represent and reuse knowledge. In the domain context, it reflects the relevant knowledge based on domain-specific concepts and relations. This is achieved thanks to activities responsible for literature review, collaboration with practitioners, and information-modelling. The contribution of the paper is that application of the reference model helps improve the quality of design science artefacts, and provides researchers with choices of techniques that might be appropriate for most design science projects.

Keywords
Design science methodology, artefact development, meta-design artefact

INTRODUCTION
We ask how unknown motives generate known acts, how unknown talent creates knowable artefacts. Those who have carried the load in philosophy have always realized that we require assistance in addressing these very varied and fascinating topics (Herrman 2009). We want to employ techniques that make success more available -more frequent, consistent, correct. The study of such techniques is methodology. We understand it as a collection of procedures, techniques, tools, and documentation aids which helps the systems developers in their efforts to implement a new information system. A methodology consists of phases, themselves consisting of sub-phases, which guides the systems developers in their choice of techniques that might be appropriate at each stage of the project and also helps them plan, manage, control and evaluate information systems projects. … ‘But a methodology is more than merely a collection of these things. It is usually based on some philosophical view; otherwise it is merely a method, like a recipe’ (Avison et al. 1988).

Since 2004, Design Science (DS) research methodology has received increased attention in computing and Information Systems (IS) research (Iivari 2007; Kuechler et al. 2008). It has become an accepted approach for research in the IS discipline, with dramatic growth in related literature (Carlsson et al. 2011; Osterle et al. 2011). DS is also considered a research orientation, within which one can use different research methods (Iivari et al. 2009). However, its current stage does not offer consistent and comprehending phases, which will guide researchers in their choice of techniques (Alturki et al. 2011). Thus, in this paper we present a reference model which covers techniques to develop artefacts for the meta-design phase in DS. Application of these phases is to systemize knowledge before an instantiation of the artefacts is deployed.

This paper is organized as follows. The next section reviews the design science research literature and proposes its challenges and potential ways of further development. Based on that review, the subsequent sections present our reference model that contains phases for meta-design step in design science methodology. Next, we justify the selection of subjective information quality dimensions as a technique to evaluate outcomes of the model, and evaluation results up to date. This paper helps define future directions and phases of design science methodology within the full spectrum of information systems research approaches.

DESIGN SCIENCE RESEARCH METHODOLOGY
Design science focuses on creations of artificial systems. It addresses research through the building and evaluation of artefacts designed to meet identified business needs (Hevner et al. 2004). Understanding the nature and causes of these needs can be a great help in designing solutions; however, design science does not limit itself to the understanding, but also aims to develop knowledge on the advantages and disadvantages of alternative solutions (Van Aken 2005). Literature reflects healthy discussion around the balance of rigor and relevance (Hevner et al. 2004) in DS research, which reflects it as a still shaping field (Iivari et al. 2009; Winter 2008).
Views and recommendations on the DS methodology vary among papers, e.g. (Baskerville et al. 2009; Peffers et al. 2007). DS methodological guidelines from the precursors (Hevner et al. 2004) and (Walls et al. 1992), are seldom ‘applied’, suggesting that existing methodology is insufficiently clear, or inadequately operationalized - still too high level of abstraction (Peffers et al. 2007). Descriptions of activities (procedures, tools, techniques) that are needed to follow the methodology are only briefly indicated.

While working with practitioners on information systems projects we found that DS needs to be more specific and provide more details for researchers. Thus, in this paper, we present and describe a model whose 3 main activities have been identified as crucial in the development of DS artefacts (Ostrowski et al. 2012). These activities are: literature review, collaboration with practitioners, and relevant modelling techniques. The reference model examines these activities in the context of meta-design artefacts (Walls et al. 1992). For a better overview, where it fits in design science, we first introduce the distinction between design science artefacts, and its place in DS methodology.

Researchers understand artefacts as “things”, i.e. entities that have some separate existence (Goldkuhl 2004). They can be in form of a construct, model, method, and an instantiation (Hevner et al. 2004; March et al. 1995). Constructs are defined as “concepts” and “conceptualizations” (March et al. 1995) and “vocabulary and symbols” (Hevner et al. 2004). These constructs are abstracted concepts aimed for theorizing and trans-situational use. “Conceptualizations are extremely important in both natural and design science. They define the terms used when describing and thinking about tasks” (March et al. 1995). Models are not conceived as abstract entities in the same way as constructs. “Models use constructs to represent a real world situation – the design problem and its solution space...” (Hevner et al. 2004) “Models aid problem and solution understanding and frequently represent the connection between problem and solution components enabling exploration of the effects of design decisions and changes in the real world.” (Hevner et al. 2004). A method is defined as “a set of steps (an algorithm or guideline) to perform a task” (March et al. 1995). An instantiation is a prototype or a specific working system or some kind of tool (Goldkuhl 2004). Most researchers agreed on those form of artefacts e.g. (Alturki et al. 2011; Goldkuhl et al. 2010); however, the methodology to achieve them varies (Baskerville et al. 2009; Sein et al. 2011). In construction of the artefact we observe two activity layers (Goldkuhl et al. 2010): 1) design practice that produces situational design knowledge and concrete artefacts and 2) meta-design that produces abstract design knowledge (see Figure 1). It can be viewed as 2a) a preparatory activity before situational design is started and 2b) a continual activity partially integrated with the design practice 2c) a concluding theoretical activity summarizing, evaluating and abstracting results directed for target groups outside the studied design and use practices (Goldkuhl et al. 2010). Meta-design artefacts are based on data types as opposed to instances of data. Their solutions are then unreal in some way or ways according to the three realities (Sun et al. 2006), such as unreal users, unreal systems, and especially unreal problems (not held by the users and/or not real tasks, etc.). Thus meta-design produces solid and generic background for the design practice activities to construct solutions for a real environment (real people, real systems (artefacts), and real settings (Sun et al. 2006), it embraces all of the complexities of human practice in real organisations.

In our opinion meta-design activities play crucial role in the design science research methodology and the final utility of the artefact. The aim of the reference model is to guide researchers throughout the activities of meta-design step (Figure 1).
The literature review leads to review the critical points of current knowledge and/or methodological approaches on a particular topic (e.g. the sought solution). This may be seen as preparation, gathering knowledge, or building foundation on which the artefact is being constructed (Ostrowski 2011). Collaboration with practitioners reveals that the act of designing does not occur in isolation. Focus groups, direct observations, and structured interviews (Yin 2009) are the most common ways of collaborations. Thus, construction of artefacts is a living process engaging practitioners from the field. The bilateral construction of an artefact falls within the scope of engaged scholarship (Van de Ven 2007). The level of engagement may depend on the nature of sought artefacts. In terms of information modelling activities, two languages are distinguished, one that structure knowledge, and one that shapes the knowledge into the sought domain requirements (Figure 1). The former gives researchers the design rationale of a knowledge base, kernel conceptualization of the world of interest, semantic constraints of concepts together with sophisticated theories and technologies enabling accumulation of knowledge which is dispensable for knowledge processing in the real world (Mizoguchi 2003). Once the former has produced its script (Wand et al. 2002) - the knowledge base for a solution, the latter uses it for a specific domain modelling language. For example if your domain concerns processes, a Business Process Modelling Language (BPML) might be considered. These modelling techniques depend highly on the undertaken research project (Ostrowski 2011).

Next section elaborates further on the abovementioned reference model. It describes and justifies selected processes for these 3 main activities. It also presents how they all cooperate to achieve a desired solution (meta-design artefact).

THE REFERENCE MODEL

The reference model contains two processes: literature review and collaboration with practitioners. Their main roles are to 1) gather information related to the investigated domain of interest, and 2) represent the information in an understandable way to the stakeholders. The idea behind the reference model is to deliver an outcome, which combines information from these two sources. Before analysis and combination of solutions from these sources take place, each process provides its own solution. Thus, to make the analysis and combination part more effective we introduce the same modelling methods in both processes. These are the ontology engineering, which is used regardless of an investigated domain, and an appropriate modelling language, which depends on the domain. For example, if a researcher investigates a process of employee engagement, then the ontology engineering technique will represent the gathered knowledge retrieved from those two sources. Next, the researcher may select BPMN as a way to build the investigated process. Ontology engineering is to provide a repository to the final outcome. In addition, analysing and formalizing the final solution are common for both processes. Under certain circumstances a researcher may only use one of the processes to deliver a final solution. Thus, each process shall end by delivering a fully modelled and described artefact for the meta-design step. Figure 2 illustrates the overview of the reference model.

![Figure 2 the Reference Model – Overview](image_url)
information aspect of the model. We describe our approach and justification of tasks selected. This is to give a solid depth to design science researchers, who may wish to follow the reference model while investigating their problems. Second, we introduce the modelling aspect. It refers to literature review as well as to the collaboration with practitioner process. We dedicate a section for ontology engineering, which is the bridge to structure information. Then, an example of the business process diagrams methods presents how it applies when the investigated domain concerns a process. Finally, analysing and formalization of the meta-design artefact is discussed.

Literature Review

A methodological review of past literature is a crucial endeavour for any research work (Webster et al. 2002). The need to uncover what is already known in the body of knowledge should not be underestimated (Hart 1999). Some fields of study have chronically suffered from lack of proper literature review, which in turn has hindered theoretical and conceptual progress (Shaw 1995). The value or importance of an effective literature review is in ensuring that the researcher demonstrates a full understanding of the body of knowledge related to the phenomenon under study, while at the same time “should be explanatory and creative” (Levy et al. 2006). Moreover, researchers noted that the IS field may greatly benefit from an effective methodological literature review in order to strengthen IS as a field of study (Webster et al. 2002). Thus, one of central aims of our study is to address the issue of developing a detailed literature review by proposing a systematic approach that will guide researchers.

Developing Initial Scope

An initial scope specifies the domain, which will be investigated. It should be as detailed as possible. This is necessary to reduce the possibility of bias in research. For instance, without the scope, it is possible that the selection of individual studies or the analysis may be driven by researcher’s expectations. Thus, such a scope is developed in the participation of senior researcher, who has more experience in the desired domain. If, during the initial examination of a domain, it is discovered that very little evidence is likely to exist or that the topic is very broad then the domain should be cluster or decompose into the satisfactory level. This can be achieved by clustering or leaving out evidence to direct the focus of the literature review.

The components of the scope include all the requirements of the review plus some additional planning information:

- Background- the rationale of the review. It states the purpose of the research.
- The research questions that the review is intended to answer.
- Expectations of the research outcome. It describes the main functionality of the outcome and outlines the main goals for further scoping.
- The research area, which states the area of knowledge (i.e. domain) under which the research is conducted.
- Identification of topics under the domain. They provide a focus for writing (e.g. data migration).
- Stating main objectives for each topic. Usually, a statement upon which you are approaching a certain topic (e.g. to summarise the best evidence on the positive and negative impacts of cloud computing)
- Stating secondary objectives for each topic. Usually, a set of questions must be answered in order to satisfy the topic. For example: how does the process of data migration into the cloud influence business (e.g. comparing small, medium, and large organizations)?
- Identification what may be excluded from the research. Usually, it is a set of conditions that must be avoided while researching.
- Identification of key authors and the relevant work.
- Identification of potential resources. It includes search terms and resources to be searched. Resources include digital libraries, specific journals, and conference proceedings. An initial mapping study can help determine an appropriate strategy.
- Project timetable. This should define the review schedule.

The scope is a critical element. Researchers must agree a procedure for evaluating the scope. They should present their scope to their supervisors for review and criticism. The review should also be subject to an independent evaluation process (Kitchenham 2004).

A Broad Search for Materials

The aim of this step is to find as many primary studies relating to the research question as possible using an unbiased search strategy. The rigor of the search process is one factor that distinguishes this approach. Search strategies are usually iterative and benefit from (Kitchenham 2004):

- Existing reviews and the assessed volumes of potentially relevant studies.
- Various combinations of search terms derived from the initial scope.
• Checking trial research strings against lists of already known primary studies.

The search for materials must be transparent and replicable as far as possible. Thus, the review should be documented in sufficient way that the readers are able to assess the thoroughness of the search. Also, changes and justification should be applied as the search occurs. It all should be saved and retained for possible reanalysis. In Figure 2, the role plays the Found Materials document. Once reference lists have been finalised the full articles of potentially useful studies will need to be obtained.

**An Advanced Search for Materials**

Once the potentially relevant articles have been obtained, they need to be assessed for their actual relevance. Inclusion and exclusion criteria from the initial scope are intended to identify those primary studies that provide direct evidence about problems of the domain. In order to reduce the likelihood of bias, these criteria may be refined during the search process. Figure 3 illustrates that further studies will be selected for retrieval after abstracts, conclusions, and titles identified in electronic/manual searches have been appraised by the lead reviewer for relevance.

<table>
<thead>
<tr>
<th>Potentially relevant studies after screening of the electronic/manual search</th>
<th>Studies excluded from the search</th>
<th>Studies from the search retrieved for more detailed evaluation</th>
<th>Studies from the search excluded (after evaluation of full text) with justification</th>
<th>Relevant studies underlined in the Found Materials with the relevant retrieved information</th>
</tr>
</thead>
</table>

**Figure 3 Process of materials selection**

Researchers should consider discussing included and excluded papers with their advisors, an expert panel or other researchers. Also, they should check compatibility of the retrieved information by applying main and secondary objectives from the initial scope document. Once all retrieved information has been confirmed, its structuring will need to be taken into action. This is achieved by applying the ontology engineering technique described in the modelling section.

**Collaboration with Practitioners**

The aim of tasks in this process is to collect information that allows building a solution to the investigated problem. Similarly to the literature review, we use practitioners as the sources for relevant information. Additionally, we ask them to cooperate in finding the best practice solution. To build systematic development of transferable, reusable and predictable collaboration with practitioners we reached for the collaboration engineering technique (Kolfschoten et al. 2010). It focuses on designing purposeful interaction within the context of a sequence of steps that helps a group to achieve its goal (Kolfschoten et al. 2009).

**Updating the Initial Scope**

Here, researchers need to adjust the Initial Scope document on the knowledge gathered during the literature review, which might have disclosed some aspects of the domain that wasn’t known at the time of the initial scoping. Having the knowledge from literature, the researchers identify characteristics of the potential practitioners. The purpose of this is to have an overview of practitioners who would be the most suitable to form a collaboration group. This may include their roles, interrelationships, and individual interests. Aspects such as group size, participants’ age, sex, culture, educational background, or organization level are useful to customize the group (Kolfschoten et al. 2009).

**Arranging Collaboration Partners**

This task aims to form a focus group (Yin 2009). Practitioners are recruited and selected based upon predefined characteristics. It starts with the initial conversation with the practitioners asked to be involved in the collaboration to diagnose requirements and constraints. It is especially important to determine whether the practitioners have congruent or conflicting interests. Other aspects, to agree on, could be as follows:

- Participant’s expectations and commitment
- Motivation to share knowledge
- Agreement on time and allocated budget

It may be useful to give different roles to the practitioners in the collaboration process. The group’s activities should be documented and transparent as much as possible. Such document should consist of the relevant history of the group and interests, motivations, and intentions of the individual participants, and a definition of which stakeholders will represent which roles in the collaboration process (Kolfschoten et al. 2009).
Preparing for Collaboration

Preparation for work with practitioners is built using the information from the previous steps. It includes defining specific questions, which could be addressed to the particular practitioner, providing instructions for each of the activities planned, and checking equipment. This is captured in the agenda. Posing the right questions or the right instruction for the group is one of the most vital steps in a collaboration process. The questions and instructions should be not too complex, ensuring that the outcomes generated can be used as input in the next activity, and detailed issues such as voting criteria, topics, and software that will support the collaboration. A meeting to present the agenda with a general overview and getting to know each other activities should be conducted prior to the real work.

Focus Group Collaboration

Focus groups allow participants to react to other group members and to generate new ideas that might have not been uncovered in individual interviews. Focus groups, therefore, provide a reasonably rich data set and importantly it allows the researcher to draw conclusions about contrasts or similarities in the collective opinions across groups as well as the depth of dissenting opinions within groups (Gibbs 1997). Due to the open-ended nature of focus groups, moderation can be complex. The following attributes deem important when moderating a focus group (Krueger et al. 2000): (1) presenting a friendly manner and a sense of humour, (2) involving and allowing all participants the opportunity to express their views, (3) challenging participants to draw out differences in opinions and to tease out a diverse range of meanings, (4) communicating clearly, both orally and in writing, and (5) listening to the views of others, while controlling personal views. To manage a situation when team members have different opinions on how the solution should be constructed, we reach for the KJ method. One of the key attributes of the method is how well it objectively gets groups to the top priorities. Different groups can analyse the same data and will often come to the same results. (Britz 2000). It allows large numbers of ideas stemming from brainstorming to be sorted into groups, based on their natural relationships, then voted and ranked the most important ones for review and analysis. Once the result on the common goal is reached, structuring the gathered information takes place. This is achieved by applying the ontology engineering technique.

Modelling

The reference model distinguishes two main modelling languages. First one structures the knowledge base, provides semantic constraints of concepts, once either literature review or collaboration with practitioners finished gathering information. The activity is ontology engineering. The second activity is to model a solution based on the knowledge base and is highly depended on the investigated domain.

Ontology Engineering

Ontology engineering consists of task ontology (Mizoguchi 1995) which characterizes the computational architecture of a knowledge-based system. It states the domain ontology which characterizes knowledge of the domain where the task is performed. The ultimate goal of task ontology includes providing a theory of all the vocabulary/concepts necessary for building a model of human problem solving processes. Figure 4 represents our process to build such concepts.

![Figure 4 Ontology engineering process-adapted and updated from Noy and Tu (Noy et al. 2002)](image-url)
The concept of ontology engineering process has been adapted from (Noy et al. 2002). Main activities involve defining terms in the domain and relations among them; defining concepts in the domain (classes); arranging the concepts in a hierarchy (subclass-superclass hierarchy); defining which attributes and properties (slots) classes can have and constraints on their values; defining individuals and filling in slot values.

The ontology engineering, might be confused with object-oriented modelling, therefore some differences should be pointed out. Ontology engineering approach reflects the structure of the world; is often about structure of concepts; actual physical representation is not an issue. Whereas the object-oriented modelling reflects the structure of the data and code; is usually about behaviour (methods); describes the physical representation of data (long int, char, etc.).

Modelling the solution

Having the knowledge base from the previous task, the researcher builds the model of solution here. Due to the variety of possible domain under investigation, we provide an example of business process diagrams (Chester et al. 2002) using BPMN as a technique to model solutions if the domain seeks for a process. The technique starts with an overall picture of the business and continues by analysing each of the functional areas of interest. This analysis can be carried out to specify the level of detail required. The technique exploits a method called top-down expansion to conduct the analysis in a targeted way. The result is a series of diagrams that represent the business activities in a way that is clear and easy to communicate. A business model comprises one or more business process diagrams. Initially a context diagram is drawn, which is a simple representation of the entire domain under investigation. This is followed by a level 1 diagram; which provides an overview of the major functional areas of the domain (e.g. Figure 2). The level 1 diagram identifies the major business processes at a high level and gives rise to a corresponding level 2, which is its decomposition (e.g. Figure 4). This process of more detailed analysis can then continue – through level 3, 4 and so on. However it is very unusual to go beyond a level 3 diagram.

Analysing models of solution

Analysis involves collating and summarising models constructed either with the knowledge gathered from literature review or collaboration with practitioners. It should be tabulated in a manner consistent with the domain problem. Tables should be structured to highlight similarities and differences between models. The task here is to integrate models comprising natural language results and conclusions, where different models may use terms and concepts with subtly different meanings. The knowledge base structure is helpful for this task.

Following (Noblit et al. 1988), we suggest to first concern the individual models, and then an attempt is made to analyse the set of models as a whole. Issues of importance are identified and the approach to each issue taken by each model is documented and tabulated. This leads to the construction of a model, which represents the optimal solution.

Formalizing the solution

The final task of the reference model is writing up the optimal solution of the search circulating the results to potentially interested parties. This could include the supervisor, practitioners involved in collaboration or designers for the design practice phase (see Figure 1). The structure and contents of the model description depend on the domain and requirements stated in the earlier phase of design science research. The outcome of the task is a fully descriptive documentation of the modelled solution.

REFERENCE MODEL EVALUATION

To validate our approach to meta-design and the support offered in each step of the reference model, a group of students were invited to conduct research following design science methodology. Their ultimate goal was to produce meta-design artefact. Each research group was assigned with the exact same research objectives. We measured how artefacts developed with or without the reference model were fit for the intended use. In accordance with techniques for artificial evaluation (Pries-Heje et al. 2008), we reached for information quality dimensions (Wang et al. 1996). It uses assessment methodologies to measure information quality by information consumers (i.e. the artefact seekers). A questionnaire was conducted among 50 practitioners of a public organisation, who had stated the research objectives. In terms of measurement, based on the observations of (McKinney et al. 2002), we used an 11-point Likert type scale. The number 10 was labelled as “Extremely good”, while 0 as “Not at all”, and 5 as “Average”. Most questions in the questionnaire were formulated as “how is the artefact <Attributes of the Item>?”. For example, “How easy is the artefact to understand?” Figure 5 and Table 1 shows the results of the questionnaire.
The artefact built on the reference model scored explicitly better in terms of understanding and getting the key points of the solution. This concludes the usage of the model for the main purpose, which was to provide researchers with a structure way to help conduct and communicate the research outcome with the stakeholders. We claim that the reference model may constitute a consistent method for the meta-design phase in design science research methodology to guide researchers to manage information systems projects. Capability of catching key points at ease should have a positive impact on developing instantiations in the design practice phase.

### CONCLUSION

In summary, we observed challenges in structuring and standardizing phases of design science research methodology, which would guide researchers in their choices of techniques that might be appropriate at each stage of the project and also help them plan, manage, control and evaluate information systems projects. Literature review, collaboration with practitioners, and modelling were identified to play an important role in producing solutions to information systems problems in design science context. Based on these three activities we introduced and described the reference model. This model helps structure and model knowledge, which is gathered during investigation of a domain.

Our future work involves revising the model, based on users’ feedback, and concentrating on evaluation. There are other qualities of models that need to be addressed such as the ability of those using the model to solve a domain relevant problem correctly, and how the model created reflects the domain. Hopefully, this will increase the efficiency and quality of artefacts, while containing or further decreasing the cognitive effort involved.

### ACKNOWLEDGMENTS

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Table 1 Results of the questionnaire

<table>
<thead>
<tr>
<th>IQ dimensions</th>
<th>reference model</th>
<th>mean</th>
<th>st. dev.</th>
<th>n</th>
<th>IQ dimensions</th>
<th>reference model</th>
<th>mean</th>
<th>st. dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>concise</td>
<td>with</td>
<td>7.55</td>
<td>1.14</td>
<td>50</td>
<td>easy to comprehend</td>
<td>with</td>
<td>7.18</td>
<td>1.05</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>w/o</td>
<td>6.10</td>
<td>1.87</td>
<td></td>
<td></td>
<td>w/o</td>
<td>5.88</td>
<td>1.99</td>
<td></td>
</tr>
<tr>
<td>compact</td>
<td>with</td>
<td>7.82</td>
<td>1.13</td>
<td>50</td>
<td>key point</td>
<td>with</td>
<td>7.69</td>
<td>0.97</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>w/o</td>
<td>5.90</td>
<td>2.10</td>
<td></td>
<td></td>
<td>w/o</td>
<td>4.78</td>
<td>1.49</td>
<td></td>
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<tr>
<td>consistent meaning</td>
<td>with</td>
<td>7.67</td>
<td>1.13</td>
<td>50</td>
<td>interpretable</td>
<td>with</td>
<td>7.25</td>
<td>1.07</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>w/o</td>
<td>5.55</td>
<td>2.11</td>
<td></td>
<td></td>
<td>w/o</td>
<td>5.69</td>
<td>2.05</td>
<td></td>
</tr>
<tr>
<td>consistent structure</td>
<td>with</td>
<td>7.39</td>
<td>1.15</td>
<td>50</td>
<td>w/o wrong symbols</td>
<td>with</td>
<td>7.65</td>
<td>1.05</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>w/o</td>
<td>5.73</td>
<td>1.79</td>
<td></td>
<td></td>
<td>w/o</td>
<td>6.14</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>the same format</td>
<td>with</td>
<td>7.84</td>
<td>1.01</td>
<td>50</td>
<td>readable</td>
<td>with</td>
<td>7.59</td>
<td>0.98</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>w/o</td>
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<td>1.10</td>
<td></td>
<td></td>
<td>w/o</td>
<td>4.10</td>
<td>2.01</td>
<td></td>
</tr>
<tr>
<td>easy to understand</td>
<td>with</td>
<td>7.41</td>
<td>1.20</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>w/o</td>
<td>5.84</td>
<td>1.69</td>
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</tr>
</tbody>
</table>

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Figure 5 Graphical representation of the questionnaire

- **IQ dimensions**
  - Concise
  - Compact
  - Consistent meaning
  - Consistent structure
  - The same format
  - Easy to understand
  - Easy to comprehend
  - Key point
  - Interpretable
  - W/o wrong symbols
  - Readable

- **Quality of Artefacts**
  - Score range from 0 to 9
  - **Reference Model**
  - **w/o the reference model**

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REFERENCES


