PROPOSED EVALUATION OF THE USE OF K-BRIEFS FOR KNOWLEDGE ACQUISITION IN KBE

Marthinusen, Ivar; Kalavrytinos, Christos; Sivertsen, Ole Ivar
Norwegian University of Science and Technology, Norway

Abstract

In Knowledge Based Engineering (KBE), knowledge about a product family is stored in a computer system in order to automate routine engineering work. Two challenges associated with this is acquiring the knowledge from a domain expert, and to make the knowledge visible to the users of the KBE-system. One proposed tool for working with both these challenges is the Knowledge Brief (K-brief). The K-brief is a structured evolution from the A3 thinking of Lean Product Development, and can be used both as a tool for documentation and knowledge acquisition. In order to evaluate K-briefs as a tool, a questionaire is proposed as a tool for data collection during a full day workshop with various stakeholders using a KBE-system.

Keywords: Lean design, Knowledge management, Virtual Engineering, Knowledge Based Engineering, A3 thinking

Contact:
Ivar Marthinusen
Norwegian University of Science and Technology
Department of Engineering Design and Materials
Norway
ivar.marthinusen@ntnu.no

Please cite this paper as:
Surnames, Initials: *Title of paper*. In: Proceedings of the 20th International Conference on Engineering Design (ICED15), Vol. nn: Title of Volume, Milan, Italy, 27.-30.07.2015

1 INTRODUCTION

Knowledge is the backbone of any engineering task, but with increasing engineering complexity, this knowledge will be spread out across an increasing number of people. In Knowledge Based Engineering (KBE), according to LaRocca (2012), some of this knowledge is transferred to a computer for automation of routine engineering work. However, transferring knowledge is not an easy task, and there are currently three major issues with knowledge transfer to, and from a KBE system that we wish to address in this paper:

1. Getting a domain expert to externalize all the knowledge required about a specific engineering problem and detailing it to such an extent that it can be implemented by a KBE system and automated.
2. Making the KBE system transparent, so that a user can easily see the knowledge behind their KBE system if they wish.
3. Sharing the knowledge with people who are not in the same location, and who work in different time-zones.

One proposed solution to the first two issues is the Knowledge Brief (K-brief). It is a further development of A3 thinking, and is intended to give a quick overview of a specific domain of knowledge. A proposed solution to the third issue is the Virtual Obeya which is discussed in the next section. This paper will therefore propose an evaluation tool for the use of digital, and paper based K-briefs within the realm of Knowledge Based Engineering. One of the main drives behind our effort is to improve the efficiency of KBE system development by reducing waste throughout the process. This drive stems mainly from Lean Product Development (LPD) principles and aims to deliver more value to the customer.

2 BACKGROUND

The K-Brief concept leans on an established concept originated by Toyota (Klein et al., 2014). It has been developed and proven in context of Lean Product Development. In principle the idea is to provide a structured one page template (an A3 sheet) for capturing knowledge in meetings, discussions or similar events (Ulonska and Welo, 2013).
It is important to note that the A3 report, as described in the Toyota concept, is just a tool or a medium to facilitate learning and communication between a mentor and a learner. This approach is deeply rooted in the way Toyota works and is essential in order to make A3 reports meaningful. Therefore, the goal is not to create the A3 itself, but to teach the learner a scientific pattern of thinking and acting, as he is working on solving a problem. When A3 gets used in other organizations without this underlying component, the probability of A3 developing systematic, scientific thinking & acting is low. (Rother, 2009)

The A3 report aims to:
- create an unfolding story
- force oneself to filter and refine his thoughts in order to present them in summary
- be a method for teaching systematic habits of thinking/working
- be a method for building consensus (Liker, 2004)

The K-brief is an evolution of A3 thinking. As described with A3 thinking, the goal of a K-brief is to get the domain- and knowledge- expert to think, but in addition to this, the finished K-brief should also be used as a reference for domain knowledge. In fact, one of the main ideas behind a K-brief, is that the user should be able to take one glance at the K-brief, and determine whether or not the information is relevant within just a few seconds. This can be achieved by having lots of graphics representing the knowledge, but also through a recognizable K-brief structure. (Klein et al., 2014)
By having a consistent template, users not only recognize the document as a K-brief, but are also able to locate the appropriate field such as title, summary etc. much faster. Our method for structure is to divide the K-brief in two sections, where the leftmost third of the A3 sheet is reserved for metadata, and where the rightmost 2/3rds is reserved for the actual knowledge and theory. This was chosen in

part because of the many years of using this in our department, but it is also feels natural to start with the title in the top, left-hand corner where one would usually start to read when opening a book. Figure 1 illustrates an example K-brief document.

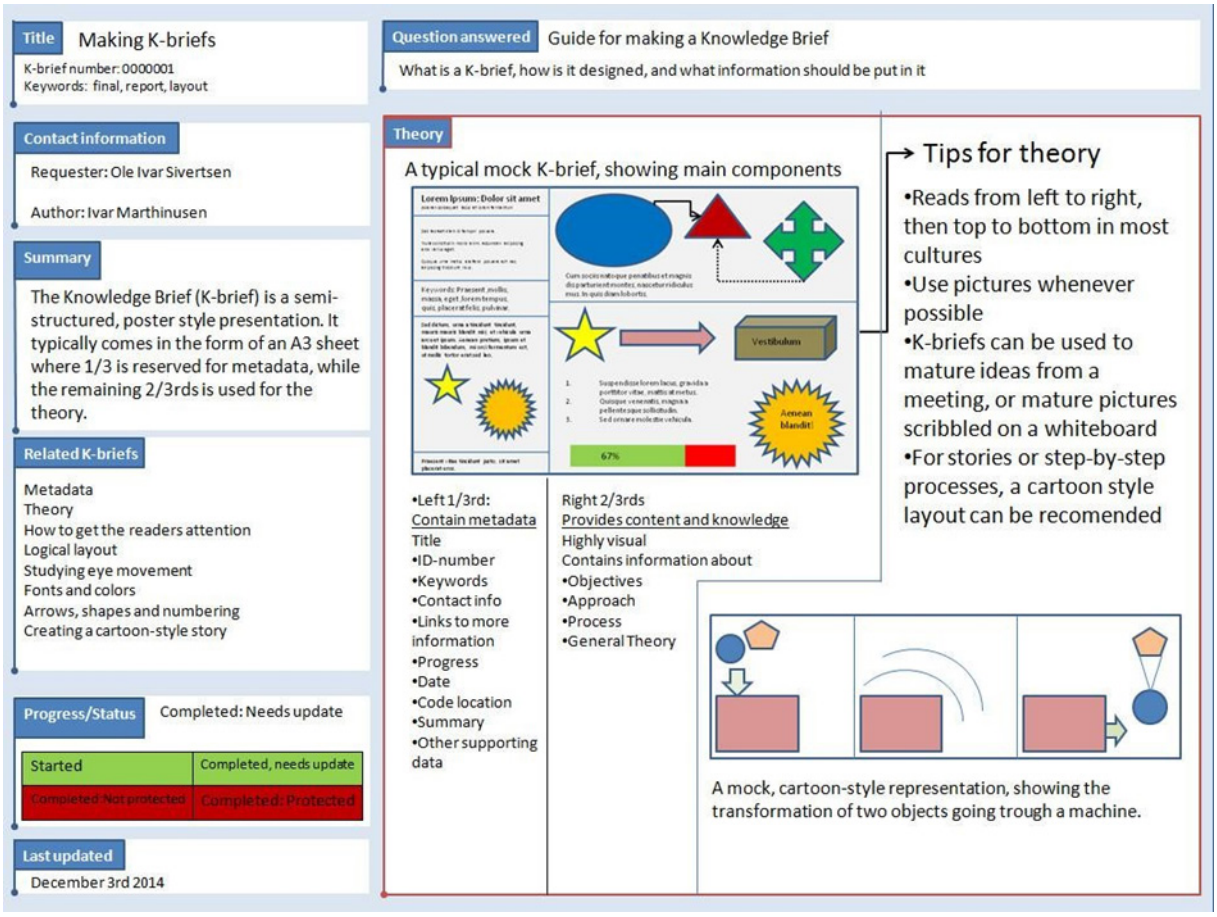

Figure 1. The above is an example to show what a typical K-brief might look like. Notice the section division.

Another concept from Japanese work-culture is the Obeya, or "large room." This is a room where all the most basic metrics of a project are visible to everyone, resulting in shorter decision-making time, and faster communication (Liker, 2004), all of which are aspects we strive to achieve in Knowledge Based Engineering (Marthinusen et al., 2014). The Virtual Obeya is an extension of this philosophy where the room exists on a big screen, so that people in split-locations can also take part in this fast communication. One of the aspects of such a Virtual Obeya will also be the digital K-brief. Originally, K-briefs have been closely connected to the Obeya concept (Aasland and Blankenburg, 2012). In the LinkedDesign project, the Virtual Obeya (VO) concept has been developed. For split location engineering collaboration connected with KBE a VO implementation is required in connection with the use of K-briefs.

The digital K-brief can be as simple as a scanned document, but should be much more in order to utilize all the capabilities a digital environment can provide such as search, online editing, versioning and more. The method for taking advantage of all these capabilities are still in development, and will continue to evolve in the future.

3 WHY K-BRIEFS?

The K-brief is not a magical solution that addresses all your problems. In the same way that a PowerPoint presentation can be excellent, or terrible, so can a K-brief. The idea of K-briefs is an evolution from the observation that during meetings, engineers tend to scribble ideas down in order to communicate relationships, geometric figures, ideas etc. The K-brief is a natural evolution for

clarifying this scribbling, and storing the data even after the whiteboard has been erased. (Klein et al., 2014)
Through working with K-briefs both at Aker Solutions, an Oil & Gas Engineering company that uses KBE, and in our university department, we have realized that the K-brief is a highly efficient tool for communicating a basic understanding of the knowledge one wishes to communicate. Because of this, it is even mandatory for all master students to provide a K-brief of their report to be posted in common areas. This leads to an easy access of the most relevant knowledge that cannot be communicated as efficiently by any other means (texts, videos, presentations, audio etc.) while also forcing the creator to refine the idea.

3.1 The need for structure

Many might say that a poster also meets all the requirements in the previous section, and to some extent, the K-brief can be looked at as a structured poster. There are many reasons for wanting a certain degree of structure, and they include, but are not limited to:

- Making the reader familiar with the K-briefs, so that they knows where on the K-briefs certain types of information can be found.
- Easing the process of making a K-brief. By having a template, we are essentially storing knowledge about what information is usually put in a K-brief.
- Easier to transfer knowledge to another medium. Maybe we find out K-briefs aren't the way to go, all the knowledge still needs to be transferred
- Easing the machine readability. K-brief search can be done through certain metadata fields such as keywords, ID, summary, contact information or related K-briefs.

Another kind of semi-structured form, usually encountered when researching KBE (Chapman et al., 2007), is the ICARE form (Illustration, Constraints, Activity, Rule and Entity), from the MOKA (Methodology and tools Oriented towards Knowledge-Based Engineering Applications) methodology, as described by Stokes (2001). ICARE is often referred to as an informal model, because it is bridges the machine readable, and the human readable world. It is a way of molding the knowledge so that it can easily be put into the KBE-system. There are, however, several shortcomings in the MOKA methodology and in real life studies on businesses using KBE, MOKA or any other KBE-methodology is seldom used, something discussed by Verhagen et al. (2012). In MOKA, the ICARE form is also thought of as the middle layer of knowledge when going from informal to formal knowledge. The K-brief is more angled towards informal knowledge, and the Linked Design project (LinkedDesign Consortium, 2014) is also investigating the use of SysML and Rule Interchange Format to represent the middle layer interface between informal and formal knowledge.

Seeing that K-briefs are so effective both at maturing ideas from a meetings into usable knowledge, and communicating knowledge to others, they are essentially designed for the purpose of solving the two first issues with KBE knowledge that is mentioned in the introduction of this paper. By making K-briefs digital, they could also be incorporated into the Virtual Obeya. Last but not least, just because something is designed for addressing a certain set of problems, doesn't automatically make it a good tool, and we will therefore in the next main section reflect upon methods for evaluating the K-brief's performance.

3.2 Maintenance of the K-brief database

One major issue regarding use of K-briefs in industry is maintenance of the K-brief database. We are limiting our evaluation of K-brief use to the documenting of the Knowledge Acquisition (KA) in connection with implementation of KBE applications. A typical KA process for implementing KBE is using a pilot KBE implementation to visualise the knowledge acquired in an iteration loop. Following KA meetings between the knowledge expert (KE) and the domain expert (DE) the KE presents an upgraded pilot KBE implementation for the DE as a verification of the knowledge acquired. Misunderstandings disclosed by the pilot implementation are followed up by further KA work to disclose the correct knowledge that should be used in the next pilot implementation. Also, if errors in the KBE application are disclosed after the initial KBE implementation is completed, a similar

procedure should be used, that is the KE and the DE should agree on what caused the error and update the application accordingly.
This work approach corresponds quite well with the AGILE principle for software development and the software engineer argues that the software itself is the source of the knowledge implemented. However, some documentation of the knowledge besides the source code should be maintained. What we argue for in this paper is that K-briefs could be the documentation that augments the knowledge implemented in the KBE application. If this is accepted our follow up argument is that K-briefs is the format that is least time consuming to implement and update – that always is the concern of the software developer.
To make K-briefs a standard documentation tool for a company developing KBE applications some key decisions should be made:

- The K-brief must be the sole documentation tool used when implementing KBE applications (See standardization in Figure 2)
- Every update of the KBE software should first start with a review of the relevant K-brief and then update the K-brief and the software.
- The K-briefs should also be the main source for the domain knowledge used in the KBE implementation for the user of the KBE application, to ensure consistency.
- A comprehensive database of K-briefs is required with versioning of the K-briefs, with two way links between K-briefs and source code, with easy access to K-briefs and related K-briefs and a comprehensive search functionality.

With these decisions made by the company we consider this approach to be the most Lean approach that could be used.

4 PROPOSAL FOR EVALUATION METHOD

In this section we discuss a method for evaluating the effectiveness of K-briefs for KBE development. In order to achieve that we need to define the stakeholders, what will be evaluated, the criteria for evaluation, the Measures of Effectiveness (MoE), the evidence that indicate whether MoEs have been satisfied, and what conclusions about the tool performance are justified.
We are proposing organizing a full day workshop with stakeholders where the concept of K-briefs will be introduced, and while working with the tool, we will take the opportunity to get participants to fill out a questionnaire regarding the tool and their experience. The justification behind this is that there is limited access to time with the stakeholders. Moreover, this approach will allow participants to gain a clear view of both the K-brief concept and clarify the questionnaire so that participants will be more likely to supply us with reliable responses. Setting this questionnaire in a workshop is also planned since this will ensure we receive a higher number of completed questionnaires. Last but not least, we are already collaborating with experts from our department that are heavily involved in engineering collaboration and a draft questionnaire has already been developed. We refer the reader to Welo for further reading of why the questionnaire is the best solution for an evaluation of any integration of Lean principles, where he sets up 6 core principles that need to be addressed as illustrated by Figure 2.

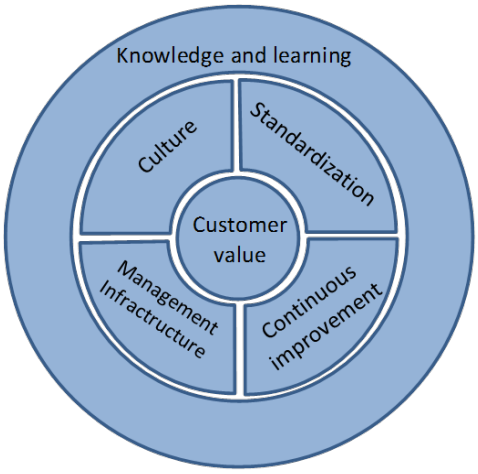

Figure 2. Lean product development: Core principles.

If K-briefs are to help a company achieve Lean-ness, the company will have to embrace these Lean principles. Customer value is at the core of these Lean principles. This is to emphasize that it is the customer, and not the company that should be at the centre of the value chain. The company needs to have a culture, strive for continuous improvement, have a management and infrastructure and wish for a standardization that all help in knowledge and learning. This means that knowledge and learning is the main tool for achieving customer value, and it is exactly this that the K-brief can be a tool in achieving.

4.1 Stakeholders

In this part we can identify the stakeholders. Even though the customer is at the core of the value chain, they are not directly involved in the knowledge and learning cycle. First in line for knowledge implementation are the developers of KBE applications, which include the Knowledge Engineer, the Software Engineer, and the Domain Experts from which the knowledge required for the system will be acquired. Secondly, the users of the KBE application that could end up using the K-briefs as part of documentation while using the application are also key stakeholders. See Figure 3 for a graphic representation of this relationship.

4.2 What will be evaluated

The focus will be on examining the use of K-brief for two distinct purposes. On one hand, we have the creation and use of K-briefs during engineering collaboration and Knowledge Acquisition. On the other hand, we have K-briefs as a tool to document and represent knowledge. In the context of KBE system development, the documentation part of their use comes as a secondary need or a by-product of the process of collaborating in order to develop a KBE application. See Figure 3 below which illustrates the use of K-briefs by the Domain Expert (DE), the Knowledge Engineer (KE) and the Software Engineer (SE).

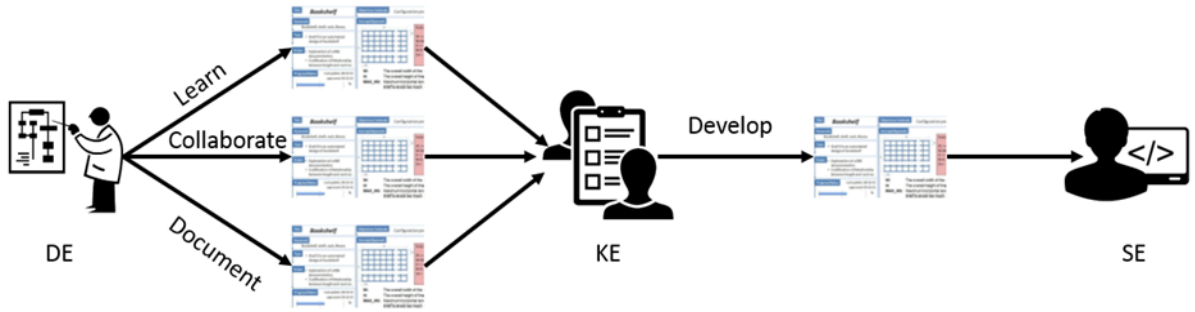

Figure 3. A view of the primary stakeholders and the uses of K-Briefs.

4.3 What are the evaluation criteria?

The K-brief, as a tool for improving knowledge and learning, has been explored for several years now, but there is still a need to reflect upon the criteria for evaluating them as a tool. For collaboration and knowledge acquisition, the criteria could include:

4.3.1 Prior experience of participants with K-briefs and KA

This criterion is focused on identifying potential bias in the responses from people with experience with K-briefs and knowledge acquisition.

4.3.2 Clarity of structured layout and content/ learning curve

One of the strongest arguments for supporting K-briefs as a documentation tool is the structured layout accompanied by the low effort required to adapt to populating the document with information. Measuring the validity of this claim is of key importance.

4.3.3 Attractiveness to Domain Experts

A basic premise for the success of K-briefs is its adoption by domain experts, especially as a tool to communicate and validated knowledge. It is, therefore, important to gauge the attractiveness of K-briefs towards Domain Experts.

4.3.4 Performance against other methods/tools

A comparison against other methods (e.g. MS documents, video/audio, etc.) is expected to provide a better insight as to what the strengths or weaknesses of K-briefs are, as perceived from the user's perspective.

4.3.5 Searchability and cross-linking

Knowledge stored on K-briefs is always referring to other K-briefs much like a hierarchy. Therefore, assessing the capability to link K-briefs together is of high value. Being able to search through relevant K-briefs is, also, a strong requirement.

4.3.6 Versioning

Having a versioning feature allows K-briefs to store the evolution of knowledge and decision-making processes. This criterion is also considered for the evaluation process as a maintainability feature.

4.3.7 Company Lean-ness

As previously stated, having a tool for knowledge and learning is of little use if the company culture does not embrace this as their core tool for achieving customer value.

4.4 Measures of Effectiveness (MoE)

The measures of effectiveness should be simple to state and measurable. A few examples are listed below, but a more comprehensive list will be available once a pilot study has been performed.

- Person hours average per K-brief creation (1 to 5 evaluation of time required)
- Number of people who prefer K-briefs to alternative tools
- Percentage of relevant search results (Searchability)

4.5 Satisfaction of MoE

The workshop with case study uses of K-briefs, and the following questionnaire should give a good indication of whether K-briefs are worth pursuing for a company, but the only real test will be as an evaluation once the K-briefs have actually been implemented.

In short, the K-brief is a tool for knowledge sharing and learning, a core principle of Lean product development. A very good way to evaluate the Lean-ness of a company, as stated by Welo, is a workshop followed by a questionnaire, and since the K-brief is a tool for achieving Lean-ness, a workshop and a questionnaire should be used here too. The questionnaire will only give an indication as to how well suited a company is for K-brief testing, and the only true test will come with full implementation. Objective measurements are hard to justify given that the K-brief experience is very subjective, and any objective measure of the company performance will be greatly influenced by any other changes a company wishes to make.

5 DISCUSSION

K-briefs appear promising, both because of their history with A3 thinking, which we argue is helpful for explicating a process, and due to the defects inherent with other reasonable alternatives. Their use

within the realm of KBE development does have its challenges though, but most of these are associated with realizing the digital K-brief. Some of these challenges include:

- The need for DEs to draw on a board/paper which needs to be transferred on the K-brief
- Lack of a versioning system since it could prove useful to be able to keep older versions of a K-brief.
- At the moment, digital K-briefs are created in simple tools such as MS PowerPoint, Word, OneNote and Google Docs, and, even though metadata and keywords are present, there is no way to search for them.

Because of these challenges, and many more, digital K-briefs will keep evolving. But they are still not useless in today's format, and it is therefore important to move to an evaluation phase even without tools such as search, cross-linking and full integration with the Virtual Obeya in place. It is, however, important to include these functionalities as a hypothetical in the questionnaires, and also ask the participants to come with other feedback that might enhance the current K-brief experience.
Good question design is challenging for a questionnaire, but this makes this pre-study even more important. By knowing our stakeholders, and having an idea of some of the criteria and measures of effectiveness beforehand, it will be easier to interpret an impartial reading of the future results. Gauging the effectiveness of turning tacit knowledge into explicit knowledge will have to be one key piece of information gained by the questionnaire.
Future development of the K-brief will be mostly to enhance the capabilities of the digital K-brief. Hyperlinking, and keyword search of web-based digital K-briefs is currently being developed as part of the European LinkedDesign project. More advanced features such as K-brief recommendations based on context-aware systems are also being explored.

6 CONCLUSION

The K-brief provides an excellent framework for knowledge elicitation, while at the same time being easy to understand for a third-party. There are however still developments that need to be made in order for the digital K-brief to reach its full capabilities.
Judging subjective criteria such as recognisability, easy to work with, and readability can be hard to quantify, but a full-day workshop with mandatory questionnaire is reasonable way to go about obtaining this data. A proposed questionnaire has also been presented in another paper.
Although we might personally enjoy working with K-briefs, a questionnaire will give the necessary data to recommend whether the K-brief should be used as a business-wide strategy, or if it is best suited for individuals who find it helpful.

REFERENCES

Aasland, K., Blankenburg, D., 2012. An analysis of the uses and properties of the Obeya, in: 2012 18th International ICE Conference on Engineering, Technology and Innovation (ICE). Presented at the 2012 18th International ICE Conference on Engineering, Technology and Innovation (ICE), pp. 1–10. doi:10.1109/ICE.2012.6297660

Blankenburg, K.A. and D., 2012. Virtualizing the Obeya. DS 71: Proceedings of NordDesign 2012, the 9th NordDesign conference, Aarlborg University, Denmark. 22-24.08.2012.

Chapman, C., Preston, S., Pinfold, M., Smith, G., 2007. Utilising enterprise knowledge with knowledge-based engineering. International Journal of Computer Applications in Technology 28, 169–179.

Klein, P., Lützenberger, J., Kristensen, K., Iversen, G., Pawar, K., 2014. K-brief and context driven access: Providing context related information to product developers in high quality, in: 2014 International ICE Conference on Engineering, Technology and Innovation (ICE). Presented at the 2014 International ICE Conference on Engineering, Technology and Innovation (ICE), pp. 1–8. doi:10.1109/ICE.2014.6871599

Liker, J., 2004. The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer, 1 edition. ed. McGraw-Hill, New York.

LinkedDesign Consortium (2014) LinkedDesign [online], www.linkeddesign.eu/ (12/12/2014).

Marthinusen, I., Kalavrytinos, C., Sivertsen, O.I., 2014. Knowledge-based Integrated Product Development, in: 2014 International ICE Conference on Engineering, Technology and Innovation (ICE). Presented at the 2014 International ICE Conference on Engineering, Technology and Innovation (ICE), pp. 1–6. doi:10.1109/ICE.2014.6871542

Rocca, G.L., 2012. Knowledge based engineering: Between AI and CAD. Review of a language based technology to support engineering design. Advanced Engineering Informatics, Knowledge based engineering to support complex product design 26, 159–179. doi:10.1016/j.aei.2012.02.002

Rother, M., 2009. Toyota Kata: Managing People for Improvement, Adaptiveness and Superior Results, 1 edition. ed. McGraw-Hill, New York.

Schon, D.A., 1984. The Reflective Practitioner: How Professionals Think In Action, 1 edition. ed. Basic Books, New York.

Stokes, M., 2001. Managing Engineering Knowledge: MOKA: Methodology for Knowledge Based Engineering Applications. Professional Engineering Publishing.

Ulonska, S., Welo, T., 2013. Need Finding for the Development of a Conceptional, Engineering- Driven Framework for Improved Product Documentation. Procedia Computer Science, 2013 Conference on Systems Engineering Research 16, 423–432. doi:10.1016/j.procs.2013.01.044

Verhagen, W.J.C., Bermell-Garcia, P., van Dijk, R.E.C., Curran, R., 2012. A critical review of Knowledge-Based Engineering: An identification of research challenges. Advanced Engineering Informatics, Network and Supply Chain System Integration for Mass Customization and Sustainable Behavior 26, 5–15. doi:10.1016/j.aei.2011.06.004

Welo, T., 2011. On the application of lean principles in Product Development: a commentary on models and practices. International Journal of Product Development 13, 316–343. doi:10.1504/IJPD.2011.042027

ACKNOWLEDGMENTS

This work has been partly funded by the European Commission through the Large-scale Integrating Project LinkedDesign: Linked Knowledge in Manufacturing, Engineering and Design for Next-Generation Production (FoFICT-2011.7.4, Project No: 284613). The authors wish to acknowledge the Commission for their support. We also wish to acknowledge our gratitude and appreciation to all the LinkedDesign project partners for their contribution during the development of various ideas and concepts presented in this paper. We would also like to thank our partners, Aker Solutions and TechnoSoft Inc. Aker Solutions has provided valuable insight into how KBE and product development functions outside of the academic world. TechnoSoft is a KBE technology provider with years of experience in all aspects the KBE process, and has provided valuable experiences and knowledge for us.