

## Requirements modelling in International Information Systems Design

– what competencies are needed and how to manage them?

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**Abstract:** Allocating the right competency to the right task is often critical in complex IS development projects, which often take place in a networked world with teams working across cultural barriers, time zones, and knowledge domains. The presented research explores knowledge and competency management issues raised in the early phases of requirement analysis in international IS design projects.

An important management challenge of requirement modelling is to balance user-facing and design-facing activities. Both domain knowledge and IS modelling skills are needed to achieve a correct and complete specification of requirements. Requirement modelling – eliciting, specifying, and evaluating stakeholders' requirements – calls on a variety of competencies. Some of these competencies can be derived from analysis of the information modelling processes, e.g., how communication in natural language with stakeholders informs visual representations of models meant to communicate precise requirements to developers of software or other IS artefacts. However, other competencies will be hard to describe, due to the complex organisation, and coordination and communication issues found in international and intercultural settings. The needed knowledge, skills and attitudes often surface only after some problem or breakdown of processes.

Competency management in ISD, particularly in internationally distributed requirement practices, is not a well researched area. Therefore, this paper focusses on understanding how the competency domain is conceptualised in these settings as a first step towards formal competency descriptions. What processes are involved, and how are competencies derived from analysing these processes? How does an international context impact on the processes and related competencies? For example, will additional competencies in intercultural communication enable a system analyst to be a more efficient modeller? In self-recruited and intercultural teams, how are the critical competences that need management identified?

This research contributes towards answering questions like these, by proposing a two-layer approach to identifying crucial competences in requirement modelling in an international context. A first layer establishes a broad set of competences identified by analysing the processes involved. The second layer of competences is a subset identified through studying breakdowns in enactment of the requirement processes. These competences are the candidates for interventions.

**Keywords:** Requirement elicitation, international ISD, intercultural competencies, requirement modelling

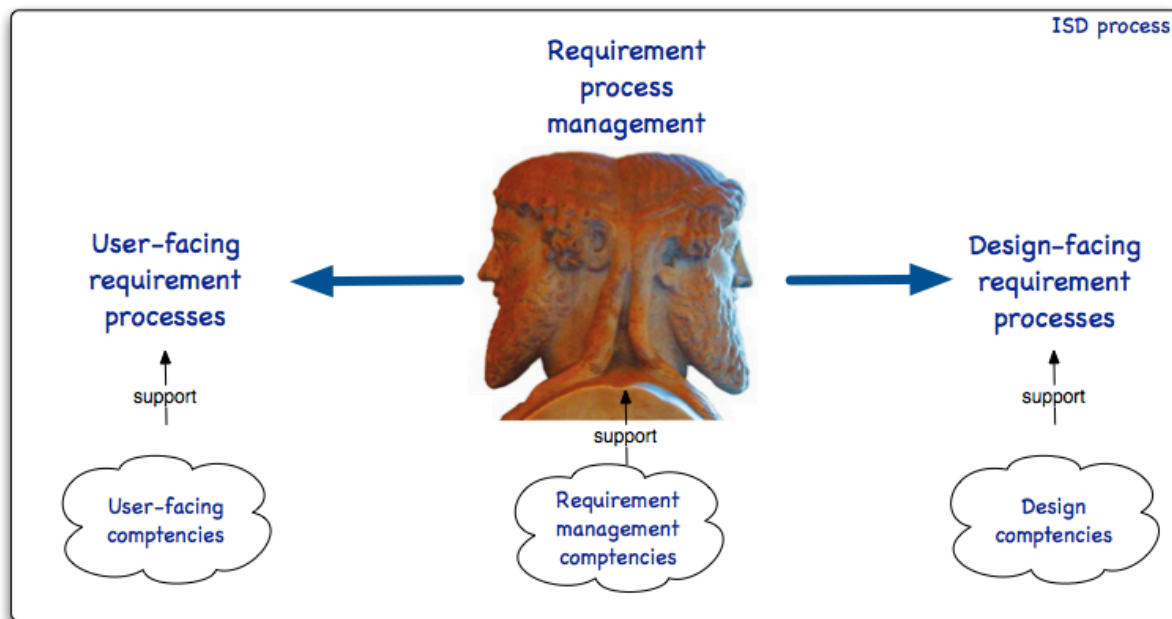
### 1. Introduction

In this paper we explore knowledge and competency management issues raised in the early, critical phases (Frederiks and van der Weide 2006) of requirement elicitation and analysis in international IS design projects. The importance of requirements for information systems success or failure has been vividly debated since the Standish Group published their first Chaos report (Standish Group, 1994). Lack of relevant user input, incomplete requirements, and changing specifications are all factors being linked to the management of a project's design requirements (Apshvalka et al. 2009; van Lamsweerde 2000). Project success or failure has also been linked to the quality and usefulness of the models representing the requirements (Rittgen 2010; Moody 2005). However, where research meets practice – when requirements and modelling methods developed through research are presented to practitioners – one may find that adoption of the prescribed methods are lagging behind. As Hansen, Berente and Lyytinen (2009) observe, the gap between research and practice runs both ways: practitioners are slow to adopt the requirements methods developed by researchers, whereas researchers often turn a blind eye to the actual practices and needs of designers.

One contribution to bridge this gap could be to look into how competencies are managed in IS design. The questions we address are related to the challenges globally dispersed design teams have to capture and represent user input throughout the IS design cycle.

- How can the necessary set of competencies for a concrete requirement modelling process be established both from a theoretical and from a practical perspective?
- How are competencies adapted to context and problem to be solved?
- What are the context factors imposed by the international settings, and how do these factors create new layers of competency requirements?

Looking at requirements in the 21st Century, Hansen et al. (2009) described an emerging landscape driven by requirement processes with a Janus face (Figure 1). Building on their model we introduce three aspects of competencies related to the requirement process that will be further discussed in this paper.



**Figure 1:** Three aspects of competencies needed in Requirement processes

The first class of User-facing competencies is directed towards working with the stakeholders, managing the user-facing activities. Eliciting diverse requirements call for particular competencies, e.g., in communicating “outside the box” of a specific computer science method or tool.

Facing the other way, the second class of Design context competencies is related to the forward looking design activities. Application domain competencies will be balanced with more generic design competencies related to systems development techniques, methods, approaches and paradigms.

The third class of Requirement management competencies is related to the management of the overall requirement process and its relation to the other ISD processes involved, their enablers and barriers. In particular, challenges related to global and intercultural development teams call for these competencies.

We will position the requirement process within an ISD context and review how literature has described the requirement knowledge creation processes in global information systems development. Based on this initial description of processes and roles in this first phase of international IS design the authors present two perspectives on developing ISD competences resulting in a first model that will be discussed in the context of two small case studies from international IT standardisation and a European software development project. This will contribute to a better understanding of competency requirements in international ISD. We follow a Design Science Approach (Hevner et al. 2004). It is based on a thorough analysis of early requirement and competency engineering, followed by modelling of new constructs to describe the identified problem space. The relevance of the created model is discussed on the background of two cases from current practice, as a first cycle of validation (Hevner 2007). However, this is a new research area and further design cycles are needed to validate the findings in this study

The rest of the paper is organized as follows. Section 2 discusses the related work with a special focus on the state of the art of research related to competency in ISD (section 2.1) and the description of requirement practices in section 2.2. Two approaches to design the competency space in ISD requirement practice are presented in section 3. In the following section 4, we demonstrate the usefulness of the approaches based on two different cases, a European project (section 4.1) and standardization work (section 4.2). The results are shown and discussed based on previous research in section 5, before section 6 presents a conclusion and short outlook on future research.

## **2. Related work**

There has been extensive research on competencies in ISD and on requirement practices. In this section relevant studies are reviewed as a background for construction of a new model.

### **2.1 Understanding competency in ISD**

The competency concept (with competence as a more specific concept) is used in many ways in different areas of research (e.g. Westera 2001; Winterton 2009; Grant and Young 2010). The recent literature on the topic agrees that the competency of a person involves knowledge (ability to think), skills (ability to act and fulfil a task), and attitudes (ability to relate to people and make knowledge and skills useful). In defining competency, it has been noted by some authors that the context of competency enactment is important (Sandberg 2000; Tessmer and Richey 1997). Pawlowski et al. (2010) have suggested that competencies only can be described if the 'competent actions' are oriented towards solving a specific problem. For this paper, competency is defined as a collection of knowledge, skills, and attitudes to solve a problem in a given context. Competence is used to refer to a specific skill or knowledge item.

While in theory, competence, methods, and practice are separate and clearly distinct elements, Omland found that in actual ISD "the three elements form close and integrated relationships" (Omland 2009). So, how do we derive competences related to the international ISD activity we are studying?

Hansen et al. (2009) found that "contemporary designers construct requirements in relation to existing systems and practices, rather than simply eliciting them as much of the literature implies" (existing systems being for example commercial-off-the-shelf applications). This observation is a warning that to construct competency profiles solely based on idealised process or role descriptions may fail. Competences are embedded in tools and practices (Hansen et al. 2009; Downey 2009), and may be hard to disentangle from the "the intrinsically dynamic relationships between actors' competence, methods, and practice in an ISD context" (Omland 2009).

Even if competences are hard to describe, when staffing projects one needs to start from some description of competences. It is been observed that the software industry tended to base their job description on mastery of certain technologies rather than knowledge, skills, and abilities, resulting in a vagueness of the advertisements unlikely to help the companies in recruiting (Downey 2009).

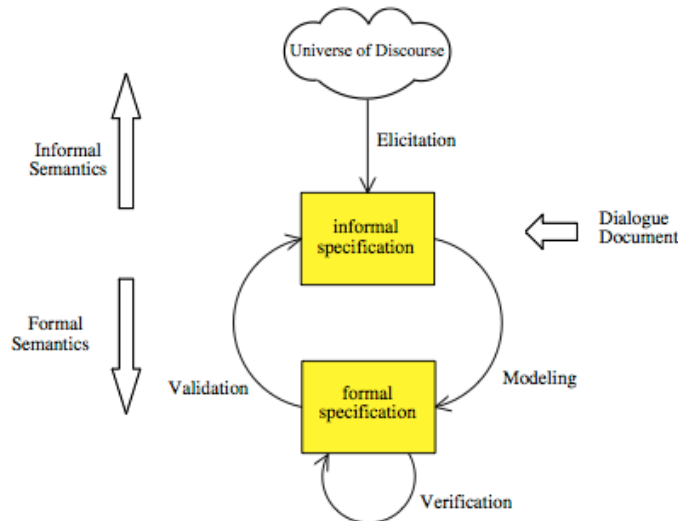
Downey (2009) proposes to move away from focussing on software development roles (Acuña and Juristo 2004; Barreto et al. 2008), which "cannot be defined in a generally applicable manner" as they vary widely between companies and projects and also overlap significantly with other roles. Instead, one should focus on the persons' contributions to the artefacts associated with the development process. These artefacts, often characterised as "boundary objects" (Star and Griesemer 1989), are "used throughout a development project to embody stakeholder knowledge and contribute to the developing process" (Downey 2009).

The artefact-centric skills approach proposed by Downey (2009) resonates with the conclusions of Omland (2009), Hansen et al. (2009), and Pawlowski et al. (2010). Competences need to be understood in the context of the existing systems and work practices. In requirement practice, one observes the "increasingly creative role that designers must play in actively co-producing requirements and artifacts, rather than simply charting out needs that are "out there" a priori" (Hansen et al. 2009).

In summary, this short review of research related to competency in ISD makes it even more pertinent to understand the problem to be solved and the context of the particular ISD activity to be able to reason about competencies in ISD.

## 2.2 Description of requirement practice

According to livari et al. (2001) the user requirements construction together with organisational alignment form the core competence of IS experts. In user requirement construction a repeated cycle of informal and formal specification take place. Frederiks and van der Weide (2006) depicted this process in a model of information modelling, Figure 2.



**Figure 2:** Information modelling process, from (Frederiks and van der Weide 2006)

Information objects from the Universe of Discourse (UoD) are described in a way that produces a document that serves as a common base for understanding and communication while designing the information system. It is clear that two kinds of expertise are involved, embodied in what Frederiks and van der Weide term a domain expert and a system analyst. “Roughly speaking, a domain expert can be characterized as someone with (1) superior detail-knowledge of the UoD but often (2) minor powers of abstraction from that same UoD. The characterisation of a system analyst is the direct opposite” (Frederiks and van der Weide 2006). Where the different areas of expertise meet, natural language is the base mechanism for communication. The domain expert does not need to have any knowledge of formal modelling languages. However, the system analyst should have some abilities to communicate with the “owners” of the problem at hand. Following Frederiks and van der Weide, “the quality of the modeling process is bounded by the quality of concretizing into an informal description augmented with the quality of abstracting from this description” (Frederiks and van der Weide 2006). Of course, the better tool support (language, models, technologies, etc.) these concretisation and abstraction processes have, the better quality of the resulting requirement documents.

In summary, it can be stated that requirement work is a complex process, in which different stakeholders and IS analysts with a diverse set of competencies work collaboratively towards solving a problem. In addition to the described knowledge areas for ISD processes, strong communication competencies are identified as a key resource.

In the next section we analyse which additional issues arise from the internationalisation of work processes and present a model of how competencies could be described in requirement practice in international ISD.

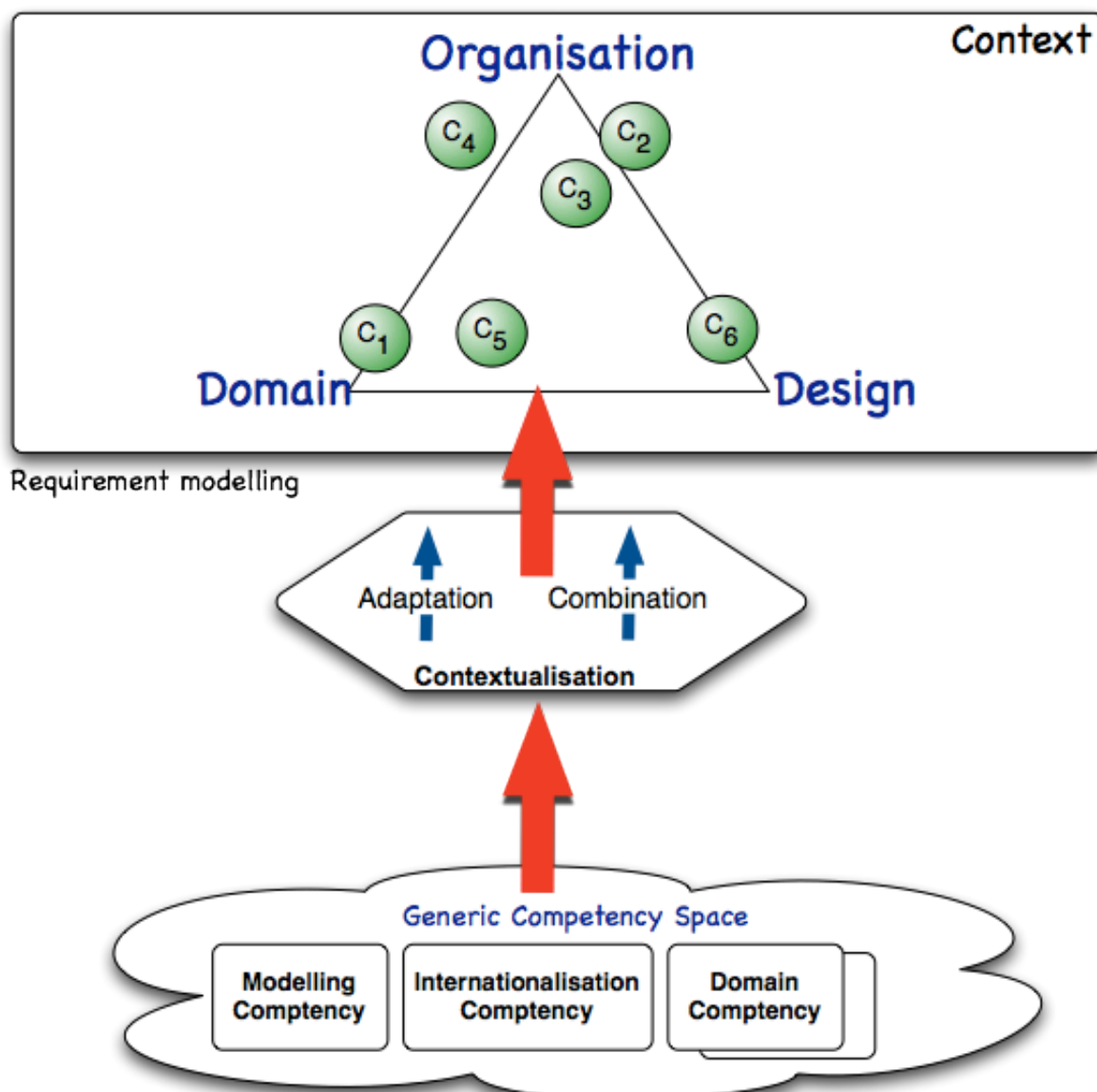
### 3. Designing the competency space in ISD requirement practice

“The distributed nature of requirements underscores the existence of multiple layers of requirements, based on differences in abstraction, user-orientation, and timing” (Hansen et al. 2009). When elaborating the three aspects of competencies needed in requirement processes, depicted in Figure 1, the distributed requirement premise needs to be understood. Is internationalisation a competency area in its own right, or is internationalisation a modifier of existing processes and related competencies, i.e., a barrier or an enabler?

Nowadays, ISD projects are run by international teams, often distributed over various cultures and time zones. Based on the geographical distance between team members communication and

collaboration are handled virtually using diverse communication and modelling tools. This globalised ISD practice makes it necessary to be able to manage all the different competencies in the requirement processes presented in Figure 1.

To support the management of competencies a two layer model was developed (see Figure 3). The model describes two distinct approaches for the creation of the requirement competency space; the deductive and the inductive approach. Within the deductive approach a generic set of competencies is created. By applying and validating this set of competencies within the context and the problem at hand the competency space is created.. The inductive approach follows a project and knowledge management perspective. The main focus here lies on the orchestration of competencies of all involved stakeholders and development team members. Through this, required competences are identified and a set of required competencies is established. In a next step the necessary distribution of competences among the stakeholders and team members is analysed. The two approaches are described in more detail in the following two subsections.



**Figure 3:** Two layer model of the competency space for the requirement elicitation

### 3.1 The deductive approach

This approach starts from a generalised “Universe of Competency” (UoC). From this UoC the relevant competencies are selected, and a set of relevant but generic competencies is built.

Requirement modelling, as described in Figure 2, requires a number of generic competences. Frederiks and van der Weide (2006) have identified a number of base skills needed for a domain expert and a system analyst. E.g., a domain expert can provide a *complete* set of information objects, and *provide* any number of significant sample sentences in relation to these objects; and a system analyst can validate a set of example sentences for *consistency* and *grammar*, and match abstract sentence structures with concepts of a *modelling* technique (Frederiks and van der Weide 2006). These problem-specific competences can be seen as context independent.

Another group of generic competences relates to the communication and coordination challenges posed by modelling in an international context. The problem at hand raises social skills challenges when negotiating and communication about objects, sentences, models, etc. The international context raises added challenges related to culture and communication. However, these competences are problem-independent and not specifically designed for the requirement modelling. In this paper these partly overlapping groups of competencies are termed Modelling competencies and Internationalisation competencies; see Figure 3.

Pawlowski and Holtkamp (2012) have identified the following internationalisation competency categories: *culture* (influences almost all aspects of a work environment); *management* (e.g., management of time differences); *communication* (e.g., common working language); *collaboration* (e.g., supported by communication technology); and *ICT* (e.g., usage of tools supporting communication and collaboration).

When an international ISD project is initiated the generic competencies have to be contextualised to fit the specific problem and context of the ISD project. For this purpose we propose the two processes adaptation and combination.

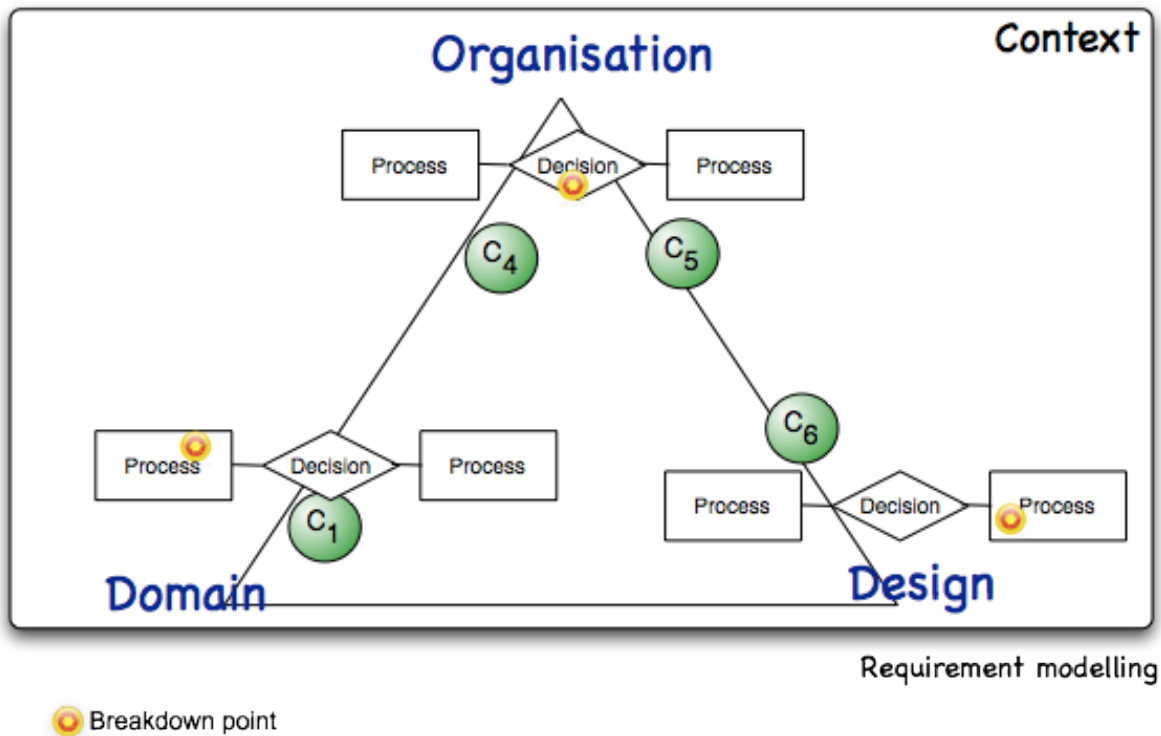
In the *adaptation*, problem and/or context-independent competencies are adapted to fit the specific problem. This could, for example, be built on the understanding how culture influences working behaviours and specific work processes to the understanding how culture influences modelling techniques. In the *combination*, competencies from different areas are combined to construct new competencies, which fit both context and problem. In the international requirement modelling could this for example be the combination of communication and collaboration competencies with the ability to take into account other cultures and their values and perspectives.

### 3.2 The inductive approach

Figure 1 presented the bidirectional metaphor of the Janus myth as fitting for describing the requirement practice. This requirement process can be depicted (Figure 4) as a triangular space formed by Domain activities facing towards the users, Design activities facing towards a formal requirement specification, and Organisational activities, managing the overall process. The activities are directed towards a problem, and happening within a specific context.

When the requirement process is instantiated one could envision that the management process ensured that the different activities had access to relevant competencies. In real life, this is not the case. The development team has already a history, roles are distributed beforehand, and everyday work takes its own course, as the reviewed literature in this paper has shown. Therefore, the competency space of a particular project has to be constructed in two steps. The first step is to establish what competences are represented in the project related to the task or problem. This is the subset of the relevant competences derived through an analysis of the generic and more specific competences (as described in section 3.1).

As a result of this first step, a list of represented and missing competences may be produced.



**Figure 4:** Identification of competences through breakdowns of processes in knowledge areas of requirement modelling

The next step assumes access to dynamic data of the enactment of the requirement process within a particular context. The development of the competency space is driven by both problem and context. E.g., a wicked problem may need particular competences in communication to elicit input from specific user groups. This information is passed on to the system analyst. However, in a culturally diverse setting, competences on how to interpret this information may be lacking, even if this type of competence is represented in the team as a whole.

From a competency management point of view, the focus of interest lies more with what could break down, than what is working fine. Therefore, the challenges of this second step are to identify potential break downs of the process that may be related to competences. The result of this second step is therefore a list of competences that needs to be managed related to certain context-specific processes. These competences may be present in the team, and the challenge is orchestration. Or lacking competences are identified, and recruitment or training actions need to be taken.

In the following we will use this model to analyse two cases within international ISD. The cases will be used to see if the proposed model is helpful in describing ISD in these settings and to suggest further development.

#### 4. Cases

The two cases are described based on participatory observations. They were selected based on their international team structure and audience, and based on the fact, that the team configuration can't be influenced by the management.

##### 4.1 Case 1: OpenScout – a European software development project

The OpenScout project aims at improving access to both professionally produced and user-generated learning resources in the domain of business administration and management. Context is a European project, and problem is software development.

During the requirement analysis and modelling three major breakdowns were identified.

The first breakdown point (lack of understanding) was caused by language problems as English was not the mother tongue of the majority of stakeholders and team members involved. It was also obvious that the two groups (domain experts and stakeholders), even if speaking English, did not

understand each other because of different terminologies and development methodologies. Because of this problem the development team started to look at similar systems to copy the approach they had taken. However, as the similar system was designed for a different domain, the development didn't fit the requirements of the stakeholders. The problem was overcome by introducing a moderator who had basic knowledge in both fields and was able to bridge the communication problem.

The second breakdown (complexity misjudgement) was based on the lack of technical competencies of the stakeholders. They expected proposed functionalities to be implemented on a very short notice and were not able to understand the development work behind a seemingly small functionality. This misunderstanding led to frustration within the development team and a raising conflict between the two sides.

The third breakdown (wrong prioritisation) was based on the lack of understanding which functionalities are most important for the domain, and how the usage would exactly take place. Based on their experience, the development team started with basic functionalities which were rather easy and quick to implement. However, these functionalities were not highly prioritised by the domain experts. The problem was solved by giving a list of upcoming functionalities to the domain expert and allowing them to prioritise what should be implemented first.

#### **4.2 Case 2: Standardisation in a formal and international forum**

This case is from international standardisation of learning technologies carried out in a formal standard setting body with a global reach. The problem was requirement elicitation concerning rights management of learning resources. The context is working group activities comprising face-to-face meetings twice a year between experts representing countries of different culture and educational tradition. The meetings are prepared by document exchange between editors before meetings.

The first layer of the competency space is about the alignment of competencies, problem and context. In this case the competencies are less aligned to the problem and context than one might expect. The participating experts are not selected because of the knowledge of rights metadata. They are standards experts nominated by their national body, not necessarily because they have a particular background in education. Even if the experts work in an international setting intercultural communication skills are not a prerequisite; e.g., the discourse during meetings tend to be dominated by experts with an English speaking background.

The second layer of the competency space is enacted when processes break down and critical competences can be identified by the analyst. In this case study we focus on two breakdowns, 1) a conflicting views on scope leading to threats of dissolving the project; 2) wilderness of draft document leading to withdrawal from negotiations.

The first breakdown is caused by differences in opinion on what is in or out of scope for the standard. An encyclopaedic, "be prepared for all cases of rights management" position is opposed by a minimal position arguing learners and teachers only need to know if the learning resources come with rights conditions attached, and what implications for use. Analysing the competency profiles of the proponents of the different positions in this conflict one observes that domain expertise in the field of education is scarcely represented.

The second breakdown is apparently caused by the length and wilderness of the draft document, which quickly grew to nearly 200 pages. In the context of this international working group it is observed that non-English speaking experts lose interest and withdraw from conversation when the documents grow beyond 100 pages. This is not necessarily due to lack of language skills. On the contrary, the reaction may be rational as the experts may not want to waste time on a standard that do not stand the chance to be implemented in their communities. The problem may rest on experts with long-drawn-out style of writing who do not have the cultural competency to design a standard that is easy to implement in an international context.

### **5. Discussion**

Competency management of the initial requirement phase of ISD activities in projects discussed in these cases offer different challenges than competency management for recruitment (Acuña and Juristo 2004; Downey 2009) and learning design (Paquette 2007). At least in theory, when hiring new staff or designing a new course offering one can start by planning what knowledge, skills and attitudes needed or should be developed. In requirement practice in international contexts on the other hand,



one has to manage the competencies that are already there and plan for the unexpected. When particular competences are missing, as discussed in the two cases, the intervention could be to strengthen the processes by allocating new persons with the needed competences. However, in many cases a likely intervention would be to launch an assessment and learning process trying to reconfigure the work processes, mobilising “hidden” competences within the current team, and embark on more development cycles than planned. E.g., when the complexity misjudgement occurred in the OpenScout project an intervention could be to re-design the requirement process so that less technically inclined project members focussed on improving natural language requirement documents. Another example from the standardisation case, when drafts seem to lose contact with practice in the “real world”, one could go back to what is called a study period, and new actors or working patterns (e.g., seminars) could be introduced.

The first research question of this paper referred to which competencies are relevant in requirement elicitation in international ISD and how they can be derived. As argued, UoC has a great number of potentially relevant competences driven by the requirement activity, which revolves around informal specification processes involving domain experts, and formal specification processes involving system analysts. In a knowledge management perspective, describing these competences gives just an inventory of the more general competency areas involved. These general competence descriptions can be used to improve understanding of the requirement processes and to prepare further actions, e.g., the learning processes referred to above. However, to be able to act upon competence descriptions they need to be contextualised (in our case to intercultural ISD work), and the descriptions need to be related to particular processes where the competence is needed. This practice-centred approach is demonstrated in the two cases where competency-related issues are surfaced when the progress of the project is in danger, and intervention is called for, not only related to competency matters.

The second research question was related to the different knowledge areas and their relation to specific competences. Based on the previous work of Iivari et al. (2001) and Hansen et al. (2009), we established the three main knowledge areas application domain knowledge, ISD process knowledge and software development knowledge. Particular competences for each of the areas in the given context should be present. However, based on the international context of the requirement elicitation and the presented influence factors, presented in section 3, new requirements for competencies were derived. Pawlowski and Holtkamp (2012) refer to these competencies as internationalisation competencies.

In the ISD practice described in the cases, matching competences to tasks is constrained in many ways. In the beginning of the requirement process nobody knows what competencies are represented in the team, as the participants are more or less self-recruited, and self-promotion does not tell much about real skills. When information about competence gaps starts to emerge, and management learns about competency profiles of individual experts, there is an organisational learning phase taking place before interventions can be designed and implemented. In this learning phase the organisation will be helped by a good understanding of the generic competences involved and how they may be contextualised, combined and adapted to support the ideal requirement processes. E.g., knowing the contextual characteristics of working with an intercultural team, differences in reasoning styles may be considered. Face saving practices may lead to a reasoning that starts with peripheral details and ends with a proposal (Scollon and Scollon, 2001) This may be very different from the reasoning style inherent in the culture that is implied by the working language, e.g., English, with the conclusion first and then what it builds on. However, it is not easy to act upon this competence in intercultural communication unless there is some sort of crisis that could justify intervention.

## **6. Conclusion and Outlook**

This paper has developed a two-layer model of the competency spaces related to ISD requirement practice. The first layer establishes and describes competences related to a problem within a context. The second layer instantiates the requirement activity as a relationship between domain activities, design activities and organisational activities. These activities call for a number of competences, which may or may not be represented in the team. The list of “idealised” competences is vetted against a history of process breakdowns that make it possible to identify critical competences in need of attention from the management function of the project. Thus, the Requirement Competency Space is a dynamic space of competences that need to be managed in order to have a successful project.

The presented model should be understood as a first step towards an understanding of how competency management is part of other management processes in requirement practices. Further

research is needed, both to develop this model and to ground the constructs in practice within international IS development. In particular the authors see a need to focus on aspects as

- Extension and validation of the presented model;
- Breakdown points caused by lack of or suboptimal distribution of competences;
- Competency management interventions to overcome breakdowns; and
- How the inductive and deductive approaches come together.

In further research, the authors will work towards integrating the two approaches in a more coherent model. One outcome of such a work will be framework for development of competency descriptions in the field of international requirement modelling, with a set of competency categories with sample competences.

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