

# The role of domain knowledge in requirements elicitation via interviews: an exploratory study

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**Abstract** Requirements elicitation is the first activity in the requirements engineering process. It includes learning, surfacing, and discovering the requirements of the stakeholders of the developed system. Various elicitation techniques exist to help analysts elicit the requirements from the different stakeholders; the most commonly used technique is the interview. Analysts may have domain knowledge prior to the elicitation process. Such knowledge is commonly assumed to have positive effects on requirements engineering processes, in that it fosters communication, and a mutual understanding of the needs. However, to a minor extent, some negative effects have also been reported. This paper presents an empirical study in which the perceived and actual effects of prior domain knowledge on requirements elicitation via interviews were examined. The results indicate that domain knowledge affects elicitation via interview in two main aspects: communication with the customers and understanding their needs. The findings provide insights as to both the positive and negative effects of domain knowledge on requirements elicitation via interview, as perceived by participants with and without domain knowledge, and show the existence of an actual effect on the course of the interviews. Furthermore, these insights can be utilized in practice to support

analysts in the elicitation process and to form requirements analysis teams. They highlight the different contributions that can be provided by analysts with different levels of domain knowledge in requirements analysis teams and the synergy that can be gained by forming heterogeneous teams of analysts.

**Keywords** Requirements elicitation · Interview · Domain knowledge · Empirical study

## 1 Introduction

Requirements elicitation is the first activity in the requirements engineering process. It includes learning, uncovering, surfacing, and discovering the needs (requirements) of the stakeholders of the intended system [1–3]. The information elicited during this process has to be interpreted, analyzed, modeled, and validated before the analysts can feel satisfactorily confident of the requirements' completeness and correctness [2].

There are various elicitation techniques to help the analysts extract requirements from the different stakeholders; the most common is the interview technique [4–10]. The analysts are not limited to one specific technique and can use different techniques according to the situation and the available time and resources [2, 11]. As the elicitation process involves different stakeholders, it is a communication-intensive process [12], in which human interactions play an important role [11]. This also leads to one of the challenges of the elicitation process: overcoming the communication barrier between analysts and stakeholders, caused partly by a gap in their domain knowledge (DK) [13]. In this context, it seems beneficial for an analyst to possess DK prior to the elicitation. When an analyst

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works on and develops a number of systems in the same domain, the knowledge gained in previous projects can be exploited and may help determine the requirements for the current project.

Prior DK might, however, also have negative effects. Studies in the field of psychology [14] show that DK may cause a tendency to approach situations in ways that have worked in the past and lead to fixation in problem-solving. Their experiments show that, when solving a creative problem, DK not only biases a first solution attempt, but also fixates knowledgeable subjects on a narrowed search space, which decreases their chances of finding an appropriate and correct solution. Furthermore, warning the subjects not to use their previously gained knowledge for solving the new problem does not improve their performance when misleading items are involved, while subjects having low levels of knowledge (but not lacking knowledge entirely) are more flexible in their way of thinking and reach correct solutions more often than the most knowledgeable subjects.

In our context, this raises the question of what the effect of prior DK on the requirements elicitation process is. This issue was initially addressed by Berry [15–17] who, based on his own experiences, indicates the importance of the lack of DK (i.e., ignorance) in RE. In [17], he notes that Buxton and Randel [18] made the same observation in 1969. Berry argues that including a smart ignoramus analyst in the RE team is important to the success of system development. The ignoramus, who has no assumptions about the domain, is more capable of spotting inconsistencies and asking questions whenever he or she notices an indication that something has been left unsaid. Berry also argues that the team must include at least one expert, who can provide the relevant information and facts.

In order to broaden and deepen our understanding of the effects of prior DK on requirements elicitation, this paper presents a study of the perceived and actual effect of DK on requirements elicitation. Requirements elicitation may involve a number of techniques, such as interviewing the stakeholders, observing their work, administering questionnaires, and so on. This study focused on the interview technique, which many researchers have identified as a substantial and leading technique [4–6, 8–10, 19]. Since we wish to uncover the possible effects related to different aspects and directions, our study is exploratory in nature, makes no a priori assumptions, and employs a qualitative research approach, combined with a quantitative one.

Accordingly, we formulated the following research questions:

*Research question 1:* What are the positive and negative effects of DK on requirements elicitation via interviews, as perceived by analysts with and without DK?

Differentiating between perceptions according to the level of the analysts' DK on which they rely means, in fact, differentiating between perceptions that rely on actual experience and those based on expectations. Analysts who have DK perceive its effects based on their actual experience in applying this knowledge, while analysts who lack DK can only speculate on its effects; this speculation can reflect the difficulties encountered by this population and provide guidance for addressing them. Another advantage of exploring perceived effects is the possibility that issues will be revealed that in practice are not always observable and measurable. Nevertheless, in addition to revealing perceptions, we wished to examine whether a difference in the actual conduct of an interview based on different DK levels can be observed and quantified. Thus, we formulated the second question.

*Research question 2:* Is there a difference in the actual interview conducted by analysts with and without DK?

This question is currently general, relating to any effect that can be observed. It will be further refined and specified with respect to a specific measurable effect based on the finding of the first research question.

In the remainder of the paper, Sect. 2 presents the theoretical background based on prior research in the area; Sect. 3 presents the methodology and setting of the study, whose findings are presented in Sect. 4. These findings are discussed in Sect. 5, and conclusions are summarized in Sect. 6.

## 2 Theoretical background

In prior studies, which refer to the importance of application domain knowledge in requirements analysis-related tasks, it has mostly been argued that it positively impacts the effectiveness of IS (information systems) problem-solving [20–27]. This is understandable, as much of what is considered to be software development is actually application domain problem-solving using software solutions [28].

However, some indications of negative effects of DK also exist, especially related to the cognitive processes involved in problem-solving and requirements definition. This section provides the theoretical background for our work, starting with the literature that addresses DK in the general context of problem-solving, then with respect to requirements engineering activities in particular. Finally, we focus on interviews with stakeholders as a requirements elicitation activity.

### 2.1 DK in problem-solving tasks

When discussing problem-solving in general, it is important to differentiate between well- and ill-structured

problems. In this context of IS analysis problem-solving, we base our differentiation on the following distinction of Kahrti and Vessey [29]:

“Well-structured problems are those that have a well-defined initial state, a clearly-defined goal state, a well-defined constrained set of transformation functions to guide the solution process, well-defined evaluation processes, and a single optimal solution path. Further, the information needed to solve the problem is contained in the problem statement. On the other hand, ill-structured problems are those for which the initial and goal states are vaguely defined or unclear, and for which there are multiple solutions and solution paths, or no solution at all. Further, the problem statement does not contain all of the information needed for their solution; hence it is not clear what actions are required to solve them” [29, p. 4]. According to this distinction, requirements analysis involves ill-structured problems.

In ill-structured problems, where the solution process is not clear and the search space is broader, creativity plays an important role. For these problems, we need to move beyond the most obvious or salient approaches to a solution and consider a broad range of more remote possibilities or alternate representations until we find one that answers our needs [30]. Creativity is also known to be important in the field of requirements engineering [31, 32] and more specifically, in requirements elicitation [33]. The cognitive psychology literature presents evidence that prior DK may constrain the analyst’s search and promote fixation in creative problem-solving attempts (see, for example, [14]). According to Wiley [14], while there is no doubt that extensive DK is critical for the solution of many problems, providing the solver with possible solutions or associations, and being increasingly beneficial as the complexity of problem-solving tasks increases, there is an inherent tension between the two roles of prior knowledge as a facilitator and as an inhibitor of creativity, as specified above. According to Chiesi et al. [34], knowledge in a given domain facilitates the acquisition of new domain-related information. However, domain experts may also judge their own performance less accurately within their own domain [14], overestimating their comprehension of a text that is within their area of expertise, whereas non-experts show a more accurate calibration of their own performance [35]. In our context, this could mean that analysts with high DK may overestimate their understanding of the requirements and thus underestimate the data that still need to be elicited, compared to their peers with lower DK. In addition, experts in a relevant domain are better at recalling or recognizing the exact information with which they were presented [14].

According to Vessey and Conger [27], the systems development tasks that are actually application domain

problem-solving tasks are particularly apparent in the first step of the systems development process. Different researchers investigated the understanding of a conceptual schema, used in the early stages of systems development [21, 23, 36, 37]. The findings of these studies indicate that DK can compensate for a lack of clarity and missing information in the representation of a problem. On the other hand, DK may incur difficulties when the available information is not consistent with this knowledge.

Kahrti et al. [23] propose that the effect of application DK is contingent upon the type of task being addressed. They found that, while DK has no effect on syntactic and semantic comprehension tasks, it aids the required processing in problem-solving<sup>1</sup> tasks; thus, performance on the schema-based problem-solving task when application DK was high was superior to when it was low. Kahrti et al. [23] underscore the importance of examining application domains in which participants have varying levels of DK in designing future studies on conceptual modeling. They also state that future research should address the underlying characteristics that render application DK useful.

## 2.2 DK in requirements engineering tasks

It has been indicated that the DK that the analyst possesses is an important contributing factor to software development in general and requirements elicitation and analysis in particular. Coughlan et al. [12] claim that eliciting requirements requires intense communication that needs to overcome any culture gap or semantic differences that may exist between users and developers. Buchman and Ekadharmawan [38] report a number of case studies as a result of which barriers to shared domain understanding among stakeholders and development teams were identified and graded. Two of the most important barriers identified are inter-group diversity and a lack of a common vocabulary. Inter-group diversity relates to different levels of knowledge, both business (domain) and technical. A lack of a common vocabulary, which can be derived from DK, may lead to time-consuming interactions and delays and to confusion and misunderstandings.

Guindon [39] indicates a specific benefit that stems from DK: the ability to deduce inferred constraints. These types of constraints may not be given explicitly in the requirements but can be deduced as a logically necessary or possible inference from the informal specification and from one’s knowledge of the problem domain. He states that inferred constraints act to reduce the incompleteness and ambiguity inherent in the requirements specification. Anton and Potts [20] also refer to the completeness of

<sup>1</sup> Note that, in this context, the term problem-solving refers to inference questions about the domain.

requirements. They claim that to achieve completeness, the analyst must go beyond and behind the stakeholders' words to discover the goals that are driving the development process. The aim is to specify explicitly the requirements and constraints that may be so obvious to an expert stakeholder that they do not seem worth mentioning. A thin spread of DK among analyst teams means that these unstated requirements may not be recognized or incorporated into the development process. Moreover, stakeholders may forget or be unaware of requirements, and analysts, without the deep DK of stakeholders, may not be able to fill in the gaps [12].

Positive effects of DK were also found by McAllister [40], who reports a field study intended to identify the factors that lead to misunderstandings regarding requirements, as perceived by users and by developers. The dominant factors that both users and developers indicate include developers' lack of understanding about the business and difficulties related to common language and terminology. Both of these factors stem from the developers possessing a low level of DK. However, another factor, indicated by both populations (although to a lesser extent), is that developers make assumptions about requirements instead of addressing questions to the users. Furthermore, users indicate that "developers know better" and create the information system they believe the users need, not that which the users requested. These two factors indicate a negative effect of a developer's DK on achieving a common understanding of the requirements. Similarly, Pitts and Browne [41] note that higher levels of experience may result in a tendency of the analyst to infer requirements rather than elicit them explicitly.

In order to understand the effect of DK on requirements determination better, we look into the difficulties that exist in the requirements process in general. Browne and Ramesh [42] categorize the difficulties incurred during the requirements process into four classes: constraints on humans as information processors; variety and complexity of user requirements; communication issues; and unwillingness of users to provide requirements. Two of these classes are relevant to our discussion: human information processing constraints and communication issues. The above-discussed advantages of DK mainly relate to communication issues, particularly language and terminology. The human information processing constraints, according to Pitts and Browne [41], relate to the cognitive processes that take place during the interaction of an analyst with a stakeholder. Through this interaction, the analyst forms a mental model of the problem domain, from which requirements are developed. The mental model builds on the information given by the stakeholder as well as that recalled from the analyst's long-term memory. The main constraints on this process are the limited capacity of the

short-term memory and difficulties in recalling from the long-term memory. These may lead to various kinds of biases in the mental model and in the derived requirements. Examples include (a) recall bias, where more salient information, such as recent or vivid events, is more accessible; (b) insufficient adjustment—a tendency to make a judgment of a situation that is anchored by some previous knowledge without adjusting it sufficiently to the current situation; (c) overconfidence, which stems from (b); (d) representativeness—categorizing a problem based on initial information and completing the problem structure by inferring from the category; (e) confirmation bias—a tendency to seek only confirmatory evidence and failure to consider alternative hypotheses. The analyst's possession of a broad DK might increase or decrease all these biases. However, to the best of our knowledge, these effects have not yet been explored empirically.

### 2.3 Interviews and DK

Many elicitation techniques are used in the requirements engineering field. The interview is a traditional technique, appropriate for eliciting non-tacit knowledge [43]. It is known to be used extensively [44] and was found as one of the most effective techniques [45].

Different aspects of the interview as a requirements elicitation technique have been investigated, with the objective of enhancing its effectiveness. These aspects usually do not relate directly to the DK of the analysts. However, some findings can be indirectly attributed to it.

One area that has received attention is recall techniques that can be used for overcoming the cognitive limitations of the interviewee. Similarly to the above-discussed cognitive limitations an analyst might experience, interviewees may also be subject to difficulties stemming from the limited capacity of the short-term memory and biases when recalling from the long-term memory.

Browne and Rogich [6] distinguish between context (domain)-dependent and context-independent prompting schemes used in interviews. They state that context-dependent schemes are usually more powerful than context-independent ones. However, in order to construct such schemes, the analyst must have significant expertise in the domain. As a generic solution, they propose and test a context-independent prompting scheme that can be reused in interviews and is independent of the analyst's DK. Taking a similar direction, Moody et al. [44] propose five principles of memory retrieval to guide the interviewee in retrieving the relevant information. For example, one principle is to use varied retrieval techniques for activating recall using different probes, for example, recalling by chronological order, forward and reverse, or from the perspective of a third party. Browne and Ramesh [42]

review context-independent and partially dependent sets of directed questions for mitigating cognitive biases in RE interviews and emphasize their contribution to the quality and quantity of the requirements elicited. They stress that questions driven by context have greater power than generalized ones, as they address a problem more specifically. This may suggest that with DK, analysts can phrase more specific, context-dependent questions, resulting in better outcomes. LaFrance suggests a categorization of possible interviewing question types [46], going from generic to specific. While the first category is “grand tour questions,” which are general and aimed at scoping and characterizing the domain, the next categories are context dependent and probe further the information given by the interviewee.

Another topic that has been studied is the “stopping rules” that analysts use, namely heuristics applied for determining when information collection can be stopped. Pitts and Browne [41] have investigated this issue with respect to interviews. They have related to a categorization of cognitive stopping rules and tried to find a connection between the stopping rule, the analyst’s experience, and the outcome of requirements determination. While they make an implicit assumption that experienced analysts have DK, they do not explicitly investigate this relationship. They list types of cognitive stopping rules, one of which seems to depend directly on DK: Stop asking questions when the pre-existing mental list of issues to be addressed is filled. Their findings indicate that this stopping rule is more effective than others.

Summarizing the reviewed literature, it is evident that, although the effects of DK on the requirements process in general and interviewing in particular have been recognized and discussed, either directly or indirectly, they have not yet been the focus of a research study. As a result, while we have evidence of some effects (both positive and negative), there is still a need for a comprehensive investigation of the types of effects and how they are experienced by analysts.

### 3 Research method and settings

The aim of the study was to gain an understanding of the perceived and actual manifestation of prior DK in requirements elicitation via interviews. As mentioned, the research is of an exploratory nature; hence, we applied a research approach combining both qualitative and quantitative methods. In particular, to address *Research question 1*—What are the positive and negative effects of DK on requirements elicitation via interviews, as perceived by analysts with and without DK?—we applied a qualitative approach. We used tools from the grounded theory methodology [47] to examine the research question through the

eyes of the participants. The study’s participants, university students, were interviewed, they filled out questionnaires, and they handed in written reports regarding their elicitation experience. In addition, relevant class discussions were observed. All the interviews and observations were transcribed. The textual data were broken down into atomic segments, which were closely examined, compared, conceptualized, and categorized. A more detailed description of the data collection and analysis is presented later in this section.

To address *Research question 2*—Is there a difference in the actual interview conducted by analysts with and without DK?—we applied a quantitative research approach to compare the interviews conducted by the two populations: analysts with and without DK. As opposed to the first exploratory question, this question required the definition of specific variables to allow a quantitative comparison. The specific variables and hypotheses were formulated based on the findings related to the first research question, as will be further elaborated later.

#### 3.1 Settings

The study was conducted in a university “Requirements Analysis Seminar” course, given to final-year IS students. As a graduation project in IS, the students are required to develop an information system for a real customer of their choice. Teams of 2–3 students perform the system development, which takes place during the final year of their studies. Each student participates in the course “Requirements Analysis Seminar” in parallel to the graduation project and is required, as part of the course assignments, to submit reports describing his or her experience in applying the different elicitation techniques that are discussed in the course. These reports include information about the data and the requirements that were elicited from the stakeholders. They also include a description of the difficulties the student encountered during the elicitation process and how he or she coped with them.

The study included two iterations, which had similar structures but which took place a year apart from each other with different groups of participants. In the first iteration, 31 students participated, and in the second iteration 38. Conducting the study in two iterations gave its findings further validation.

Each iteration included the following main phases of studying the interview technique:

1. A lecture—which was devoted to the different types of interview and how they should be planned, conducted, and analyzed.
2. Class activity—interview simulation (see details below).



3. A series of class discussions—the issues of interviews and DK manifestation were revisited during the semester, as the students progressed with their work.
  4. Field experience—the students performed interviews with their real customers, after which they were required to submit a report that described their experience. The report included a transcript of the interview and information about the data they analyzed and the requirements they elicited. It also included a description of the difficulties the students had encountered during the interviews and of how they had coped with these difficulties.
  5. Reflection questionnaires and interviews regarding the field experience—as part of the questionnaires, each participant was asked to rank his or her DK at the beginning of the project (i.e., before starting the elicitation process). They were also asked how their prior DK (or lack of it) affected the interview. In addition, each participant was interviewed about the difficulties s/he had encountered, in light of existing/missing DK.
2. Preparing for the simulations
    - The participants who played the role of interviewer in the current session received a textual description of the interview task. They were then given time to review this description and prepare questions for the interview.
    - At the same time, the participants who played the role of interviewee in the current session received a detailed textual description of the domain, so that they could fill the role of customer. The descriptions of the different domains were equivalent in length, richness of details, and complexity.
  3. After the interview simulation, the participants were given a questionnaire about the interview in general and about the influence of their level of DK on the interview in particular.
  4. A class discussion about the advantages and disadvantages of DK was held at the end of the simulations. During the discussion, the participants were asked to note what they perceived as the advantages and disadvantages of DK when planning and performing an interview.

A detailed description of the class activity—interview simulation:

Two domains were chosen for each iteration of the study. The participants were paired; in each pair, one was an interviewee and the other an interviewer for one domain, and for the other domain, they switched roles. The following steps were included:

1. Evaluation of the participants' DK.
  - The participants were asked to fill out two questionnaires regarding their familiarity with the two different domains (see Table 1 below). These questionnaires included several questions about the students' past experience, both as users and as analysts, in the domain at hand, and a final question of self-evaluation about their knowledge. Based on these questionnaires, two researchers independently classified each student as having high- or low-level DK, and agreement has been reached for the classifications of all students.
  - Based on the participants' knowledge evaluations, they were assigned to play the role of interviewer, forming four groups of interviewers:
    - i Interviewers in Domain 1 with high-level DK;
    - ii Interviewers in Domain 1 with low-level DK;
    - iii Interviewers in Domain 2 with high-level DK;
    - iv Interviewers in Domain 2 with low-level DK.
  - Each participant was paired with a participant who was assigned to be an interviewer in the other domain.

Note that not all the students participated in the simulation sessions (some were absent on the simulation days); 27 out of 31 participated in the first simulation iteration, and 31 out of 38 participated in the second simulation iteration.

### 3.2 Data collection and analysis

The data collected during the study included: (a) the documented interview questions prepared for the class simulation; (b) the questionnaires (pre-DK evaluation and post-reflection) of the class simulation and the field experience; (c) the reports handed in by the participants summarizing their experience with the field interviews; (d) the interviews conducted by the researchers with the participants; and (e) observations of class discussions during the semester.

#### 3.2.1 The qualitative analysis relating to research question 1

Textual phrases from all data sources were analyzed to identify the categories of perceived positive and negative effects of prior DK on requirements elicitation via interviews (research question #1). The data were analyzed based on concept analysis according to the inductive analysis approach. In this approach, categories emerge from the data and are validated and refined during the analysis process [47, 48]. The purpose of inductive analysis

**Table 1** Participant's DK (questionnaire-based)

Iteration	Domain 1	Domain 2	Number of participants (interviewers)		
			With DK	Without DK	Total
First iteration	University library	Law firm	13 (7 in domain 1)	14 (6 in domain 1)	27
Second iteration	University registration	Biomedical experiments	15 (All in domain 1)	16 (All in domain 2)	31

is to identify recurring themes, which serve as the basis for the categories, and to define their properties and dimensions. This purpose was consistent with our aim of identifying the effects of DK on requirements elicitation via interviews.

The data-analysis process included open, axial, and, finally, selective coding [48]. During open coding, the data were fractured into segments. We isolated 239 segments that were composed of participants' various statements, opinions, answers, and so on, obtained from the questionnaires, written reports, interviews, and observations. In the first analysis of the segments, we classified these segments into two groups: positive (222 segments) and negative (17 segments) effects of DK. Next, for each group of segments, we coded and classified the segments into iteratively emerging categories. For example, the segment "If I had more domain knowledge I could have asked more focused questions and received more detailed information" was coded as "helps focusing questions."

The axial coding included the process of understanding how the categories identified in the open coding related to each other and classifying categories under common themes, thus creating hierarchical classifications. For example, a relationship between the codes of "helps focusing questions" and "helps covering all relevant issues" was created and later combined with additional categories to create the common theme of "supports understanding the customer needs."

In the selective coding process, a theory was sought that would identify a coherent phenomenon related to the effects that emerged in the previous phases. The coherent phenomenon found during this analysis was that the perceived DK effects during requirements elicitation via interviews are positive with regard to the communication with the customer and both positive and negative with regard to understanding the customer's needs. It should be noted that, in our study, the perceived positive effects exceeded the perceived negative effects.

The data were iteratively analyzed after each phase of data collection (e.g., class activity, actual customer interviews, interviews with the students, class discussion, etc.). Category saturation was achieved during the second phase of the second iteration. In addition, to obtain some

quantification that would indicate the relative importance of the different categories, we counted the number of segments classified into each category.

### 3.2.2 Hypotheses formulation and data-analysis approach relating to research question 2

The findings of research question 1 enabled us to select an effect that is both substantial and measurable with which to address research question 2, which relates to an actual effect of DK. Specifically, one effect: "DK helps in focusing questions" was found to be emphasized above and beyond other effects, according to the number of segments. Furthermore, Browne and Rogich [6] and Browne and Ramesh [42] discuss the differences between domain-independent and domain-specific prompting schemes and emphasize the superiority of domain-specific ones. This led to the following direction being taken for answering research question 2. In order to determine whether there is a difference in the actual interviews of analysts with and without DK, we decided to test the focus (i.e., domain specificity) of the interview and its questions as prepared by participants with and without DK. We assumed that participants who have DK would tend to phrase more focused, specific questions, while participants without DK would tend to phrase mostly general questions, which do not require deep DK. The questions asked by the participants were therefore categorized as specific (questions that relate to specific context in the domain) or general questions (that could be asked for almost any kind of system). For example, a specific question was "What happens when a reader does not return a book on time?", and a general question was "How many users are expected to use the system and what are their roles?"

Accordingly, we formulated the following set of hypotheses.

H<sub>0</sub>1: There is no difference between analysts with and without DK in terms of the amount of specific questions in an interview

H<sub>1</sub>1: The amount of specific questions in interviews conducted by analysts without DK is smaller than in interviews conducted by analysts who have DK

- H<sub>0</sub>2: There is no difference between analysts with and without DK in terms of the amount of general questions in an interview
- H<sub>1</sub>2: The amount of general questions in interviews conducted by analysts without DK is larger than in interviews conducted by analysts who have DK

We analyzed the questions from the class simulation and the field experience separately, in order to distinguish the controlled (but artificial) class setting from the less-controlled (but real) field setting. Since in both settings, the number of specific and general questions per interview was not normally distributed, we analyzed the data using Wilcoxon two-sample test. In the second iteration of the class simulation, two students without DK did not document their questions, and thus were not included in the analysis.

### 3.3 Validation with practitioners

Using only students as subjects, simulating practitioners, is always a threat to external validity and may compromise generalization of the findings. In order to mitigate this risk, we interviewed experienced requirements analysts to further validate, and possibly refine, our findings. In this phase of the research, five experienced requirements analysts were interviewed. These five practitioners varied in their educational backgrounds and professional experience. The interviews were semi-structured, each about 1 h long, and included the following main steps:

1. Requesting general background about the interviewee
2. Presenting the general topic of the research
3. Advantages/disadvantages of DK
  - a. Open questions: what are the positive and negative effects of DK?
  - b. Focused questions: discussing each positive/negative effect of DK as stemmed from the findings of our research.
4. The effects of high/low-level DK on the type of interview questions
  - a. Open questions: Based on your own past experience, are there differences in the type of questions you ask when you have high and low DK?
  - b. Focused questions: discussing our findings regarding general/specific questions in different levels of DK.

All the interviews were transcribed and qualitatively analyzed. Specifically, the text was fractured into segments, and each segment was either classified to an existing effect category or marked as not classified. All unclassified segments were later analyzed similarly to the

analysis in the previous phase, yielding one additional effect category.

Addressing only the open questions part of the interview, we noted for each interviewee and for each category whether the category was mentioned (at least once). Further, we noted whether it was emphasized (mentioned several times, induced a lengthy discussion, or was underlined with adjectives such as “critical”, “important”, etc.).

In the focused questions, each analyst was asked to express agreement or disagreement with the findings presented to him/her and to add some personal view. We counted the number of agreements and applied further qualitative analysis to the discussion text.

## 4 Research findings

This section presents the findings of the study. We start by addressing the first research question concerning the *perceived* positive and negative effects of DK in requirements elicitation via interviews. Afterward, we address the second question, relating to the *actual* effect on the course of the interview.

### 4.1 Perceived effects of DK

We distinguish between the perceptions observed by participants with DK and those without it. As explained, we categorized the statements that were collected from the participants into a list of the positive and negative effects of DK in terms of requirements elicitation via interviews and counted the number of statements (segments) in each category as an informal indication of their relative importance. Table 2 presents the categories of positive effects of DK related to interviews. The table separately presents the number of statements in each category made by participants with and without DK. Below, we discuss the categories that most frequently appeared in the participants' statements.

The most dominant positive effect of DK that the participants indicated was that it helps in focusing questions. This was mainly indicated by participants who had DK, but also, to a lesser extent, by participants who did not. Being familiar with the domain, an analyst can more easily prepare focused questions for an interview. A typical statement referring to this positive effect made by a participant with DK was: “The questions were phrased based on my familiarity with the domain and with systems for managing it, and therefore the questions were more focused and to the point.” A typical statement made by a participant who lacked DK was: “Had I known more [about the domain] I would have asked more specific questions and not just



**Table 2** Categories of perceived positive effects of DK

Perceived positive effects	# of statements made by participants with DK	# of statements made by participants without DK	Total
Helps in focusing questions	73	34	107
Provides a common language with the customer	15	13	28
Helps in phrasing comprehensible questions	18	9	27
Helps in directing the interview	13	9	22
Helps in covering all the relevant issues	6	12	18
Saves the time of learning the basics	3	8	11
Knowing what needs to be improved/preserved	4	1	5
Sharing knowledge with other team members	1	3	4
Total	133	89	222

about the roles and main processes.” The advantage of asking focused, specific questions, according to the participants’ statements, was the ability they confer on the interviewer to elicit specific information that would not have been obtained by more general questions.

Another noteworthy advantage of DK, indicated to a similar extent by participants with and without DK, was that it provides a common language with the customer. The quotes regarding common language referred to the conversation with the customer during the interview. Typical statements in this category were: “My knowledge contributed to my understanding of the customer and the terms he used.”; “The lack of domain knowledge made it difficult for me to understand the customer’s language; it was hard to understand his explanations about the existing systems.”

The next advantage also refers to communicating with the customer, in the context of preparing comprehensible questions, using appropriate terminology, to explain accurately to the customer what information is sought. The quotes regarding comprehensible questions referred to the preparation phase prior to the interview. This effect was noted mostly by participants with DK. Examples of statements of a participant with DK: “I was able to phrase comprehensible questions that the customer could easily understand,” and without DK: “The nature of the questions was less professional [in terminology] regarding the discussed domain.”

The perceived help of DK in terms of directing the interview was also indicated. It relates to the interviewer’s ability to assess in real time the information given by the stakeholder in terms of relevance and clarity and to decide how to proceed with the interview. An example statement in this category: “I had some experience in this domain. Therefore I was able to lead the interview and get the interviewee to talk so that she would give me a more accurate answer on this subject.”

Another positive effect, which was indicated to a greater extent by participants without DK is that it helps the interviewer cover all the relevant issues. A typical statement in this category of such participant: “It could be that some of the processes were missed during the interview, and there was no way for me to know it.” This suggests that analysts without DK may be more concerned about the completeness of the knowledge gained than analysts that have DK.

Looking for commonalities in the different categories in Table 2, we found that two main themes concerned our subjects: their thorough understanding of the customer’s needs and their ability to communicate with the customer. The categories were classified into these main themes as presented in Table 3.

One exception was the category “Sharing knowledge with other team members.” While all other categories related to the effect of DK on an individual analyst, in this category the effect related to the analysis team, in which the individual analyst does not benefit but rather contributes to others. This is a broader effect, which extends beyond a single interview, and affects the project in general.

The data analysis also yielded statements indicating perceived negative effects of DK. These were fewer than the indicated positive effects. Table 4 provides the perceived negative effects of DK and the number of statements made regarding each of them.

The table clearly shows that negative effects of DK were mainly indicated by participants who had DK. These were derived from difficulties they experienced during the interview. This implies that the participants who lacked DK could not even, in most cases, perceive these kinds of difficulties.

The negative effect that was most indicated was a fixed point of view. Typical statements indicating this effect

**Table 3** Perceived positive effects classified to main themes

Main theme	Perceived positive effects	# of statements made by participants with DK	# of statements made by participants without DK	Total
Understanding the customer's needs	Helps in focusing questions	73	34	107
	Helps in directing the interview	13	9	22
	Helps in covering all the relevant issues	6	12	18
	Saves the time of learning the basics	3	8	11
	Knowing what needs to be improved/preserved	4	1	5
	Subtotal	99	64	163
Communication with the customer	Provides a common language with the customer	15	13	28
	Helps in phrasing comprehensible questions	18	9	27
	Subtotal	33	22	55
Total		132	86	218

**Table 4** Perceived negative effects of DK

Perceived disadvantage	# of statements made by participants with DK	# of statements made by participants without DK	Total
Fixed point of view	6	2	8
Missing information due to perceiving questions as trivial	4	0	4
Contradictions in the points of view	5	0	5
Total	15	2	17

were: “Domain knowledge sometimes makes it difficult to listen to the customer. It seems [to the analysts] that they know the answer better than the customer”; “Domain knowledge makes it difficult because you view things from your point of view and your preferences about what you want to include in the new system.” This fixation may lead to neglecting to incorporate the new information elicited.

A second negative effect was missing information due to perceiving questions as trivial. One of the participants wrote: “I did not ask trivial questions. Looking back, maybe there was room for that... Since I did not ask, I have basically decided the answer for the customer, when his actual answer might have been different.” This stands in contrast to a previous finding: the perception of DK as contributing to the completeness by helping the analyst to cover all issues. Neglecting to ask seemingly trivial questions may hinder the elicitation of relevant information. We may hence conclude that it is not certain that the effects of DK on completeness and correctness during the process of understanding the needs are positive.

The third negative effect mentioned is a possible contradiction between the views of the stakeholder and the analyst. This occurs in situations where the information given (by the stakeholder) contradicts the knowledge the

analyst has about the domain. In the words of one participant: “The interviewer may think of the domain in a different way from the customer, which requires him [the analyst] to adjust his line of thinking and this is not simple.” This is a difficulty with which the analyst has to deal. On the other hand, this can also be exploited for verifying the information given by the stakeholder, or for suggesting new ideas to the stakeholder (i.e., the analyst takes a proactive approach, suggesting improvement ideas) and may therefore eventually bear positive results.

Looking at the categories of negative effects of DK, we can see that they all refer to understanding the customer's needs and none to the communication with the customer. This may stem from one of two causes: (1) in general, the communication theme is less represented (see Table 3), and since we only had a few negative statements, it was simply not represented in this small sample, or (2) analysts do not perceive communication with the customer as something that may be negatively affected by DK. In order to determine which conjecture is correct, we returned to the class and conducted a class discussion with the study participants that dealt with the question of negative DK effects on communication with the customer. The students did not mention any suggestion of such an effect. While

**Table 5** The number of specific and general questions in interviews in both settings

DK	N	Number of specific questions				Number of general questions			
		Mean	Median	SD	p value	Mean	Median	SD	p value
<i>Class simulation</i>									
Lacks	28	1.68	1.00	2.48	0.029	9.43	8.00	4.72	0.389
Exists	28	2.57	2.00	2.39		8.75	8.00	3.83	
<i>Real customer interviews</i>									
Lacks	12	1.00	0.00	1.60	0.010	8.33	8.00	4.87	0.125
Exists	9	4.67	4.00	4.00		6.44	4.00	6.00	

this does not prove that such an effect does not exist, it reassures us that communication with the customer does not seem to be perceived as being negatively affected by DK.

#### 4.2 Actual effect of DK on the interview

The most dominant effect, as perceived by participants both with and without DK, was its support in phrasing focused and specific questions. Hence, to study the actual effect of DK on the interview, we analyzed the questions that the students formed and presented to the interviewees in the two different settings: class simulation and real customer interviews. We present the findings from the two settings separately. The questions asked by the participants were categorized as specific (questions that relate to details of the processes to be supported by the system) or general questions (that could be asked for almost any kind of system). As stated earlier, the study examined two sets of hypotheses, relating to the number of specific questions (H1) and the number of general questions (H2).

Table 5 shows the findings related to Hypotheses 1 and 2 based on the data obtained in both settings. Note that the interviews at the real customers site were performed by teams of participants (2–3 participants a team). Hence, N in that setting represents the number of teams.

The findings in Table 5 indicate that  $H_01$  can be rejected in both settings. The confidence level in the real customer interviews ( $p$  value = 0.010) is higher than in the class simulation ( $p$  value = 0.029). A possible explanation is that when facing an interview with a real customer, the participants had more time and invested more effort preparing for the interview. This resulted in the participants who had DK presenting more specific questions. In both cases, however, it is clear that participants with DK phrase a higher number of specific questions than participants without DK.

Regarding the number of general questions, according to Table 5, in both settings  $H_02$  cannot be rejected ( $p$  value = 0.389 in class simulation,  $p$  value = 0.125 in real customer

**Table 6** Interview types

DK	N	Mostly general	Mixed	p value
<i>Class simulation</i>				
Lacks	28	21 75.00 %	7 25.00 %	0.028
Exists	28	13 46.43 %	15 53.57 %	
<i>Real customer interviews</i>				
Lacks	12	11 91.67 %	1 8.33 %	0.046
Exists	9	4 44.44 %	5 55.56 %	

interviews), even though there are differences in the mean number of general questions between the two populations. Thus, we do not have evidence that analysts without DK compensate for the lack of specific questions by asking a higher number of general questions.

To gain deeper insights into the differences in the structure of the interviews between the two populations, we further analyzed them by categorizing each interview as mostly general (up to 25 % specific questions), mixed (between 25 and 75 % specific questions), and mostly specific (75 % specific questions and up). Since the number of mostly specific interviews in the entire data set (both settings) was negligible (3), we merged this category with the category of mixed interviews. The results are shown in Table 6. In class simulation, only 25 % of the interviews conducted by participants without DK were of a mixed nature as compared to approximately 54 % of the interviews by participants who had DK. This phenomenon is even more significant in the real customer interviews, where only a single interview conducted by participants without DK (approximately 8 %) was mixed, as opposed to approximately 56 % by participants that had DK. Statistically, these differences are significant with  $p$  value = 0.028 for class simulation and  $p$  value = 0.046 for real customer interviews.

As the findings indicate, while participants who lacked DK mostly asked general questions, those who had DK were able to phrase their questions more specifically, which could result in gaining a deeper understanding and eliciting more details. We may hence conclude that the ability to phrase focused and specific questions is not only a perceived positive effect of DK, but also an actual one. This finding supports an affirmative answer to the second research question, namely that there is a difference in the actual interview conducted by analysts with and without DK. While this single effect is sufficient for this determination, additional effects may also exist.

### 4.3 Validation with experienced requirements analysts and further refinement

The findings reported above were further validated and refined through interviews with five experienced requirements analysts. The five interviewees differed in their educational background and professional experience. Two of the analysts had a Bachelor degree, two had a Master degree, and one had a PhD, gained in different institutions. Their professional experience in requirements analysis ranged from 8 to 16 years. They also held different professional positions: two have worked in consultancy firms dealing mostly with off-the-shelf systems; two have worked in IT divisions of enterprises, dealing with both in-house development and off-the-shelf systems, and one who has been involved in both position types, as well as in requirements definition for software products.

As explained in the research method section, the interviews were transcribed and qualitatively analyzed. We have classified text segments according to the categories found in the previous study or marked them as not classified. Further analysis yielded one additional category of a positive DK effect: Enables using the interview for promoting collaboration in the organization. Addressing only the open questions part of the interview, we noted for each interviewee and for each category whether the category was mentioned (at least once), and further, whether it was emphasized (mentioned several times, induced a lengthy discussion, or was underlined with adjectives such as “critical”, “important”, etc.). We counted the number of interviewees that mentioned each category, and among them, the ones that emphasized it. In the focused questions, each analyst was asked to express agreement or disagreement with the findings presented to him/her and to add some personal view. The results are summarized in Table 7 (positive effects) and Table 8 (negative effects).

In general, the data obtained from the experienced analysts supports the previous findings: All categories were mentioned, although in several cases with a different emphasis as compared to the students. Below, we discuss the

**Table 7** Positive effect categories in the experienced analyst interviews

Perceived positive effects	Mentioned	Emphasized	Agreed
Helps in focusing questions	4	0	5
Provides a common language with the customer	2	2	5
Helps in phrasing comprehensible questions	1	0	5
Helps in directing the interview	4	2	4
Helps in covering all the relevant issues	5	0	5 <sup>a</sup>
Saves the time of learning the basics	4	2	5
Knowing what needs to be improved/preserved	4	3	4
Sharing knowledge with other team members	1	0	3
<i>New</i> : Enables using the interview for promoting collaboration in the organization	4	2	NA

<sup>a</sup> Three mentioned that DK might also have a negative effect on completeness

**Table 8** Negative effect categories in the experienced analyst interviews

Perceived negative effects	Mentioned	Emphasized	Agreed
Fixed point of view	5	4	5
Missing information due to perceiving questions as trivial	3	1	4
Contradictions in the points of view	2	2	4 <sup>a</sup>

<sup>a</sup> All four emphasized that this could be positive, depending on the analyst's attitude

categories where such differences were observed, as well as the new category that emerged from these interviews.

**Helps in directing the interview:** As seen in Table 7, this category was mentioned by four analysts and emphasized by two. Those who emphasized this category repeatedly referred to a priori knowledge of needs, to which they lead the interview. One of the analysts did not agree with the existence of this effect nor that it would be positive. The analyst claimed that directing the interview is affected by interviewing skills (rather than DK) and that in some cases, it might be better to let the interviewee lead the interview (rather than imposing the interviewer's line of thinking and priorities).

**Helps in covering all relevant issues:** While all analysts mentioned this positive effect in the open questions, three

of them indicated that DK might also have a negative effect on completeness. For example, one analyst, who said “without DK you don’t know what you don’t know; with DK you extract from the customer important issues you would not encounter without a specific knowledge-based question,” also said later when asked specifically about this category: “sometimes you may miss information due to prior knowledge, when you do not come open-minded.”

**Knowing what needs to be improved/preserved:** This was the least frequently mentioned positive category in the students’ study. In contrast, here it was highly emphasized. For example, one analyst explained: “With DK you can spot the strengths and the weaknesses of your customer and identify what competitive advantage you can offer; without DK you cannot improve the customer’s processes.” Similar statements were made by three others. Still, one of the analysts disagreed that this should be considered part of the analyst’s responsibilities: “What needs to be improved/preserved is for the customer to decide.”

**Sharing knowledge with other team members:** This category was mentioned by only one analyst in the open part of the interview. When asked about it specifically, three agreed with this positive effect. The other two, both working in consultancy firms, expressed doubts about the willingness of knowledgeable analysts to share their knowledge with other team members. They brought examples of considerations that may impede knowledge sharing. For example, one analyst said that in mixed teams, including employees from different consultancy firms, analysts might refrain from sharing their knowledge with members from other firms. Moreover, another analyst even expressed reluctance to knowledge sharing within the same firm. “I do not tend to share knowledge with my team members. I worked hard to gain this knowledge, and it gives me a competitive edge within my firm.”

**Enables using the interview for promoting collaboration in the organization:** This new category covers considerations raised by the analysts with regard to the role of DK in handling organizational politics and human relations, in preparation to future change propagation in the organization. These include (a) the selection and screening of interviewees, for example, more knowledgeable employees, or employees who might cause difficulties in later stages of the project; (b) creation of a positive and collaborative attitude toward the project: “common language and DK remove barriers and lead to ‘brothers in arms’ style collaboration.”; and (c) resistance management, which relates to both interviewee selection and an upfront discussion of potential obstacles raised during an interview. “DK helps to predict and handle resistance to changes. It is crucial not to leave unattended concerns even at the very beginning.”

This new category, similarly to the category of “sharing knowledge with other team members,” does not merely affect a single interview, but is intended to contribute beyond the requirements phase of the project. Hence, it does not belong in the main elicitation themes identified.

Considering the negative effects, these were far more acknowledged by the experienced analysts than by the students. Moreover, insights into the sources of these effects were indicated.

**Fixed point of view:** There was a consensus among the analysts about the existence of this negative effect. However, while the students referred to cognitive sources of this effect such as bias and fixation, the experienced analysts mentioned additional sources. For example, “analysts who consider themselves as ‘Gurus’ in the domain will not listen; they only want to be listened to”—reflects ego-driven behavior. Another source, which was emphasized by the analysts who work for consultancy firms, was cost considerations. “The fastest and most efficient way to get the customer’s money is to duplicate the previous project. In such atmosphere, the analyst is consciously not interested in the unique needs of the current customer.”

**Missing information due to perceiving questions as trivial:** This category was highly emphasized by three of the analysts, especially by those who work for the consultancy firms. “I am impatient and not attentive enough when I think I know the answer. Sometimes I don’t even let the customer complete the sentence; at times it turns out that although I thought I knew what he meant, I actually didn’t.” Still, one of the analysts did not agree with this category, saying “It’s not necessarily bad; if it were important, the customer would have brought it up.” We note that this analyst has been involved in agile development projects in recent years and consistently stated that it is not important to know everything upfront.

**Contradictions in the points of view:** Four of the analysts agreed with this category and two emphasized it. The fifth agreed that this would be a negative effect, but claimed that it happens rarely. However, all analysts indicated that this could also positively affect the analysis process, as it can drive discussion and overcome bias. There is an interesting difference in the attitude of analysts as compared to students. The students who indicated this effect were concerned about the difficulty of coping with contradictions. Their statements reflected an underlying assumption that in any conflict the customer is always right. In contrast, the analysts’ perception of the possible benefits of contradictions implies that they are confident enough not to fear this situation. When discussing the negative aspect of this, their main concern was that this conflict might trigger ego-driven behavior rather than content-oriented



resolution. “It is possible that conflicting views might lead to ego conflicts between two experts, becoming like an arm-wrestling arena.”

Finally, we discussed with the analysts our findings regarding the types of questions used with and without DK. All the analysts noted that our finding is aligned with their professional experience. “General questions need to be asked in any case. When you have DK it’s easy to also get to specific questions, which make the ‘real’ conversation. If you have no DK, this conversation ends quickly.”

We note that along the interviews, we consistently found differences in the analysts’ points of view, which were clearly aligned with their professional experience and background. Two main observations should be mentioned. First, the two analysts who work for consultancy firms repeatedly indicated considerations of cost and efficiency as well as preservation of competitive advantage. These considerations were not mentioned by the other three analysts. Second, the analyst who is accustomed to the agile development approach expressed time and again reservations toward striving for requirements completeness.

In summary, the findings of the interviews validate and strengthen our findings from the students study. All the positive and negative effects were supported by the experienced analysts. They also expressed agreement with the findings of the quantitative study, indicating that these are aligned with their professional experience. In addition, while only a few students recognized the negative effects of DK, all the experienced analysts emphasized these effects. Furthermore, the analysts indicated sources for these effects that have not been raised by the students, as they reflect aspects of project reality and are not purely driven by customer needs’ considerations. Based on these interviews, it might even be suggested that DK enables analyst behavior, which is not necessarily in the best interest of the customer, when a motivation for such behavior exists. Finally, a new category of positive DK effects was identified.

## 5 Discussion

### 5.1 Analysis of the findings

As presented in the Findings section, the perceived effects we have identified relate to two main themes: the communication with the customer and the understanding of their needs.

**Communication support:** Our findings show that DK supports the communication between the analyst and the stakeholders. Specifically, using the domain terminology enables the analyst to present questions that the stakeholders

can understand and to comprehend precisely the answers that are given. This is consistent with the findings of many earlier investigations [38, 49].

**Understanding of needs:** Our findings indicate that DK can positively as well as negatively affect the formation of the analyst’s deep understanding of the customer’s needs. The completeness and correctness of the requirements elicited are, on the one hand, positively affected by DK, which enables the analyst to know which issues need to be addressed and refined. The perceived effect, “helps in covering all the relevant issues,” was mainly indicated in the students’ study by participants who lacked DK and might have experienced difficulties in applying a satisfactory “stopping rule” (see [41]). The perceived effect of “helps in directing the interview” relates to the ability of the analyst to lead the interviewee and prompt information. According to Pitts and Browne [3], due to the representativeness heuristic, previously developed information systems judged to be similar to the analyzed system are used as a basis for identifying requirements. With this anchoring, the analyst may ask questions about issues that the stakeholder might otherwise have forgotten. This anchoring can also be related to the identified perceived effect of “knowing what needs to be improved or preserved,” emphasized by the experienced analysts. In addition, according to Browne and Rogich [6], the stakeholders might provide partial or biased information, due to their cognitive constraints. In these situations, relying on their knowledge and familiarity with similar systems, analysts can direct the interview to clarify the requirements. In contrast, an analyst who lacks DK does not have familiar similar systems on which to rely and will have to rely solely on the information given by the stakeholder without knowing whether this is all the information required. In general, it can be said that DK supports a context-specific proactive elicitation approach, with the analyst leading the interview, suggesting improvement ideas, and verifying the information given against this knowledge. These all support the completeness and correctness of the resulting requirements.

On the other hand, DK may also negatively affect the completeness and correctness of the requirements. Being overconfident or time-constrained, the analyst may neglect to ask questions the answers to which seem obvious. In addition, having DK, the analyst might tend to force his own point of view rather than be attentive to that of the customer. This finding is consistent with the findings described by Wiley [14] concerning domain knowledge as causing fixation in problem-solving. In addition, according to Pitts and Browne [41], there is also evidence of a tendency to force similarity when it is inappropriate, which may lead to unjustified assumptions. According to McAllister [40], one

of the factors that hinder the requirements process is that developers make assumptions about requirements instead of addressing questions to the user. Our interviews with the experienced analysts suggest that this cognitive phenomenon can be amplified by cost and ego considerations. It was indicated in our students' study that contradictions between the information given by the customer and the prior knowledge of the analyst create difficulties that the analyst has to overcome. According to Pitts and Browne [41], analysts might even seek only confirmatory and ignore contradictory information.

Considering the focus and emphasis of the elicitation during the process of understanding the customer needs, the most prominent effect that stemmed from exploring the students' perceptions was the ability to present focused and specific questions. This was corroborated further in a quantitative study based on the actual interviews and validated with experienced analysts. This tendency to present specific questions is commonly associated with a contribution to the effectiveness of interviews in requirements elicitation [6]. It should also be noted that this finding implies that the participants chose to ask specific questions when they could and were not content when they felt unable to do this because they lacked DK. The tendency to ask specific and focused questions is aligned with the general finding of Kahrti and Vessey [29] that problem solvers in a familiar application domain engage in a more focused search than those in an unfamiliar domain.

## 5.2 Limitations

Three main limitations of the study should be noted. First, the participants in the main study were students, who are not experienced analysts. Their limited experience in performing elicitation might have been reflected in the way they performed the tasks and in their perceptions of the effect of DK. In addition, when an experienced analyst lacks knowledge in a specific domain, she may still apply knowledge gained in other domains by making an analogy, as opposed to students who have not gained much experience. Kitchenham et al. [50] argue that using students instead of software engineers as subjects is not a major issue, provided that the research questions are not specifically focused on software development experts. Moreover, it was empirically found that students have realistic expectations of industry requirements engineering practices and thus may work well as subjects in empirical investigations that are generalizable to a larger population of requirements engineering professionals [51]. Nonetheless, we have decided to reduce the generalizability threat further by validating the findings through interviews with experienced analysts. As described above, these interviews confirmed the findings of the students' study and further enriched them.

Second, the research approach to identify perceptions regarding DK effects was qualitative, with an attempted quantification of importance based on the number of statements classified into each category. This quantification can be regarded only as an indication of the relative importance or extent of the effects, rather than as corroborated claims. Future research may take a more quantitative approach design based on the findings of this exploratory study.

Third, when considering the actual effect of DK, our settings allowed us to apply quantitative measurements only to the questions prepared by the participants for the interviews with the customers. We did not have documentation of the actual interviews. This, combined with indications that focus is a key issue affected by DK, led us to measure this specific aspect. Further research may address other effects identified in this research.

## 5.3 Main implications for practice

Following this research, we indicate the practical implications on requirements elicitation, concerning three different populations: analysts, project managers, and customers.

Implications and recommendations for analysts: Analysts who lack DK need support in both obtaining a complete understanding of the customer's needs and communicating with the customer. Using domain-independent prompting schemes [3] can contribute to the completeness of the elicited information. However, these schemes are not helpful for overcoming the communication barriers. To support the communication with the stakeholders, it is advisable that analysts without DK would learn the domain terminology before the elicitation sessions. Other preparations may include reviewing existing systems in the domain to enrich the analysts' DK and provide them with a sense of completeness and anchoring, and thus a position from which they can prompt the interviewees.

Analysts who have DK need to avoid fixation and preconceptions that might lead to incomplete and inaccurate understanding of the customer's needs. To this end, we recommend these analysts to start interviews with several general open questions, allowing the interviewee to express needs and expectations in a relatively unguided manner. This may reveal issues that the analyst might (wrongly) take for granted.

Implications and recommendations for project managers: When a team of analysts conducts the elicitation, a combination of different levels of DK can be beneficial, as suggested by Berry [15–17]. The analysts who have DK can facilitate communication, focus on details, and promote a proactive approach. Furthermore, as indicated in our study, they can share some of their knowledge with their team members. However, this sharing needs to be

promoted and motivated, to overcome situations of knowledge hiding due to considerations of competitiveness and job retention, referred to in our interviews with experienced analysts. In addition, an important role should be played by the analysts who lack DK, by asking the so-called ignorant (but intelligent) questions that expose tacit assumptions that are incorrect [15–17], preventing both fixation and the analysts taking information for granted. Note that according to our findings the negative effects of DK are mostly not recognized by analysts who lack it. Hence, the important role of the less knowledgeable analysts should be announced and explained to all team members.

Special attention should be given to the role of so-called Gurus, namely highly knowledgeable and reputable experts, in the team. Our findings indicate potential hindering behaviors, such as over-confidence, ego-driven conflicts with interviewees, and dismissal of the less knowledgeable team members. On the other hand, these experts have valuable knowledge that can significantly contribute to the project. Furthermore, their reputation promotes the quality of service as perceived by the customer, leading to higher trust and cooperation. Accordingly, the specific role assigned to such an expert in the team should utilize the benefits while attempting to avoid the potential pitfalls discussed, taking into consideration the personas involved and the specific situation.

Implications and recommendations for customers: customers of consultancy firms usually wish to be assigned teams of highly experienced and knowledgeable consultants (analysts in our case). As an implication of this study, customers should be aware of the important role of less knowledgeable analysts and their potential contribution to the completeness and accuracy of the requirements. Moreover, attention should be given to the possibility of DK to support analyst behavior, which is intended to save time and cost at the expense of achieving a real understanding of the customer's needs. Such behavior is sometimes motivated by the firm's policies and objectives or by individual job security considerations. Customers' awareness of these risks should enable mitigating them, identifying situations where these behaviors emerge, and carefully steering the project to their satisfaction.

## 6 Conclusions

The objective of the study reported in this paper was to gain an understanding of how DK affects the way analysts conduct requirements elicitation via interviews. This was achieved mainly by investigating how analysts with and without DK perceive this effect. In addition, we investigated whether there is a difference in the nature of

the actual interviews conducted by the two different populations.

The insights as to both positive and negative effects of DK on requirements elicitation via interviews provided by this study can be utilized in practice to support analysts in the elicitation process and to form elicitation teams. They highlight the different roles that can be played by analysts with varying levels of DK in requirements analysis teams and the synergy that can be gained by forming teams of analysts with and without DK. It is additionally important, however, to take into account the findings of Vessey and Conger [27] that application knowledge is idiosyncratic, which makes it necessary to include more than one application-knowledgeable person in a systems analysis team.

While our findings are mostly consistent with prior literature, the previously reported phenomena have not been specifically addressed in the context of DK. Hence, the main contribution of this study is in providing empirical evidence of the manifestation of DK with respect to previously documented observations. Additionally, our findings indicate underlying considerations, beyond cognitive phenomena, that may enhance the identified effects. We have explored the perceived effects of DK and the differences in these perceptions between subjects with and without DK. Furthermore, we have established the existence of an actual difference between the interviews conducted by these two populations.

Future research can build on the findings of this study and formulate hypotheses regarding additional actual effects that can be quantitatively corroborated. In addition, our findings indicate some organizational circumstances that may enhance specific effects of DK. Future research may further investigate these relationships in industrial settings.

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