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RESEARCH NOTES

In Search of Information Systems (Grand) Challenges

A Community of Inquirers Perspective

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Abstract The paper reports on the results of a Delphi study with 143 information systems (IS) academics that was designed to explore what IS academics perceive to be the grand challenges of the IS discipline. The results provide evidence that the scholarly IS discipline is still much concerned with itself, for instance, in terms of its identity, relevance, foundational theory, or methodological pluralism – suggesting that the old debate on IS identity is not yet overcome. It thus cannot be claimed that the study identifies the grand challenges of the discipline – still it becomes noticeable that the academic community sees potentials for the IS discipline to have societal impact. A total of 21 challenges are identified, of which six challenges are categorized as "meta challenges for further developing the IS discipline" and the remaining 15 challenges are categorized as "IS research challenges" pertaining to socio-technical systems, IS infrastructures, society and ecology, as well as social well-being and affectivity. We provide a ranking of all challenges according to their relevance, potential impact, and possible time frame of realization. The results have some important implications for IS as a discipline as well as its prospective future societal role. It is hoped that through our study we can contribute to the important debate on the challenges of the academic IS discipline.

Keywords Grand challenges · IS research · Delphi study · IS community · Research impact

1 Introduction

What are the grand challenges of a scientific discipline? Finding the Higgs boson or flying to the moon were grand challenges and could only be achieved through collaborative, cross-disciplinary efforts and the allocation of considerable resources. In physics, biology, or medicine it is – often even for the layperson – easy to identify some grand challenges. They personally matter to us (e.g., in the case of medicine), they have highly visible societal consequences (e.g., in the case of using alternative energy sources), or they are frequently in the news (e.g., in the case of CERN's Large Hadron Collider).

But what are the challenges of the information systems (IS) discipline? Considering that IS have been the major contributor to economic growth and productivity over the past decades (Watson et al. 2010), this question definitely warrants our attention. While considerable effort has been put into identifying such challenges (Dickson et al. 1984; Brancheau and Wetherbe 1987; Niederman et al. 1990; Brancheau et al. 1996; Kappelman et al. 2013; Dekleva and Zupancic 1996; Krcmar 1990; Moores 1996; Wang and Turban 1994; Watson 1989; Yang 1996; Luftman et al.

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2013), the answers are still not obvious, and different scholars are likely to name different challenges, if asked. And, indeed, the IS field is characterized by its diversity (Schwartz 2014) as well as dynamic technological development. Big data, the internet of things, or cloud computing are just a few examples of developments that could not even be envisioned a few years ago. Diversity has been identified as both a strength and weakness of our discipline (Robey 1996; Benbasat and Zmud 2003; Benbasat and Weber 1996). While diversity is desirable in terms of contributions from different research communities in the sense of "disciplined methodological pluralism" (Landry and Banville 1992), it is our contention that identifying grand challenges might help develop an ideal of collaboration (Robey 1996) and thus foster both effectiveness and efficiency in IS. Researchers can more easily pinpoint relevant topics and can share and communicate their results. Research is a collaborative effort, and we need to understand where resources should be best allocated.

Against this background, we believe that it is worthwhile to investigate what the community of IS scholars, which forms a community of inquirers (Peirce 1877; Seixas 1993; Constantinides et al. 2012), considers their grand challenges. We feel that it is important for us to understand what *we aim to accomplish as a discipline* as well as what *challenges we face as a discipline*. As a community of inquirers, the IS field is characterized by its social context and is built upon certain intersubjective agreements among its members (Peirce 1877; Seixas 1993). While there has been intensive debate on the subject of inquiry, that is, the core of the IS discipline (Benbasat and Zmud 2003), there is considerable agreement that this community of inquirers is concerned with the development, use, and effects of IS artifacts. Our essential research question is:

> *What are the grand challenges of IS research from the perspective of the community of inquirers?*

In order to seek answers to this question, we use three perspectives and corresponding questions:

1. What are the grand challenges of IS with regard to solving problems of specific domains (i.e., using IS artifacts to solve problems)?
2. What are the grand challenges of IS that are independent of specific domains (i.e., phenomena related to the IS artifact itself, such as integration, complexity, usefulness)?
3. What are the grand challenges of the IS discipline with regard to its further development?

The first and second question relate to what the discipline should study with regard to its primary units of analysis (IS artifacts, individuals, groups, organizations, governments, society) in terms of the development, use, and effects of IS. The third question asks how the discipline should position itself to accomplish its goals. In order to seek answers to these questions, we conducted a preliminary workshop with 17 participants, a qualitative two-round Delphi study involving 14 IS researchers, and a subsequent quantitative two-round Delphi study involving 113 IS researchers.

Our work contributes to the debate on the important question of what the IS discipline should study. Specifically, we contribute to our discipline's understanding of its major goals as a community of inquirers. While the target (i.e., the grand challenges) is moving along in a dynamic discipline such as IS, this does not mean that we shouldn't think about what we should study *now*. We also expect that the grand challenges of our discipline will take years and considerable resources to be solved, and that new grand challenges will emerge.

The remainder of this paper is structured as follows. First, we present related work on grand challenges in general and in IS in particular. This is followed by the research design and the results section. We then discuss our findings, highlight limitations, and conclude with a summary.

2 On Grand Challenges of Scientific Disciplines

Research on grand challenges and key questions of scientific disciplines, or research fields, has a long tradition. There are different approaches to identifying grand challenges, including conferences, summits, workshops, or, indeed, Delphi studies.

In the field of engineering, for instance, Bathia (2013) summarized the results of the "Global Grand Challenges Summit" held at the Institution of Engineering and Technology in London in 2013 on challenges for Engineering and International Development. McKone et al. (2011) elaborated on the grand challenges for life-cycle assessment of biofuels that resulted from "research planning and progress meetings of the Life-Cycle Program of the Energy Biosciences Institute at the University of California, Berkeley" (McKone et al. 2011, p. 1). Mönch et al. (2011) called for research on the grand challenges for discrete event logistics systems in a special issue of the journal *Computers in Industry*. Wheeler et al. (2011) did the same for the grand challenges in Neuroengineering in a special section in the *IEEE Transactions on Biomedical Engineering*.

In Medical Science, He et al. (2013a) summarized the results of the discussion on grand challenges in interfacing engineering with life sciences and medicine, held during the first IEEE Life Sciences Grand Challenges Conference

in 2012. Furthermore, He et al. (2013b) presented the results of a discussion (three grand challenges on engineering and mapping the brain) of the NSF Workshop on Mapping and Engineering the Brain in 2013. Singer et al. (2007) investigated the grand challenges for global health in the context of the Grand Challenges in Global Health Initiative.

In the IS discipline, the debate on grand challenges dates back to the 1980s, when Dickson et al. (1984) initiated a sequence of related studies with a Delphi study on the key issues of information systems management. They vindicated their work by stating that the "information systems profession is continually faced with making difficult decisions about the commitment of its limited management, research, and educational resources" (Dickson et al. 1984, p. 1), and that "a widely accepted and current assessment of the important management issues in information systems does not exist" (Dickson et al. 1984, p. 1). Their Delphi study consisted of four rounds, with the participants being IS professionals, mainly from leading positions (IS executives) in the United States. The study was repeated three years later by Brancheau and Wetherbe (1987), this time with a three-round Delphi study. Niederman et al. (1990) repeated the study again to determine the grand challenges of IS management of the 1990s, also with a three-round Delphi study. In 1996, another three-round Delphi study was conducted by Brancheau et al. (1996). Finally, a recent study by Kappelman et al. (2013) determined the key issues of IT organizations and their leadership by conducting a survey with IS professionals.

A number of studies have investigated grand challenges from the perspectives of specific countries. A two-round Delphi study by Hayne and Pollard (2000) with 157 Canadian participants identified critical IS issues in Canada. Dekleva and Zupancic (1996) used the Delphi technique to determine key issues in information systems management in Slovenia. A German perspective was described by Krcmar (1990), who conducted a survey, asking German IT executives of large and medium-sized enterprises for current issues of the field. Moores (1996) investigated key issues in the management of information systems with a survey in Hong Kong. A Chinese perspective on management information systems (MIS) key issues was presented by Wang and Turban (1994). Watson (1989) used a three-round Delphi study to establish the most important MIS issues of Australia. Yang (1996) surveyed Taiwanese companies for their key MIS issues and compared the results to MIS issues from the USA. Finally, a recent study of Luftman et al. (2013) investigated key information technology and management issues from an international perspective. They conducted the same survey in four different geographic regions (U.S., Europe, Asia, and Latin America) questioning IS/IT professionals in these regions and comparing the results. Also recently, Mertens and Barbian (2015) studied the views of the business informatics discipline that much characterizes the German-speaking IS community.

Grand challenges research in the field of IS/IT has further been conducted for different sub-fields of the discipline. Lai and Chung (2002), for instance, identified top ten issues for international data communications management in a two-round Delphi study. The three-round Delphi study of Viehland and Hughes (2002) elaborated on future scenarios for the wireless application protocol. Winter (2012) presented an argumentative paper where she proposes and discusses grand challenges for eCommerce, and Hoare and Milner (2005) investigated grand challenges for Computing Research by conducting an exercise with an expert panel. Similarly, the German Informatics Society used expert opinions to formulate five grand challenges of informatics (Gesellschaft für Informatik 2014).

To summarize, there is a considerable body of knowledge on grand challenges. Typically, these studies focus on an IT/IS practice perspective by either questioning IT/IS professionals or academics. It is our contention that identifying grand challenges from the perspective of IS academics – that is, from that of the community of inquirers – will provide an insiders' perspective which helps us understand two things: what we aim to accomplish *and* how we need to further develop our discipline in order to do so. Besides, prior work has primarily focused on specific countries/regions and differences between these regions (e.g., Yang 1996). Considering the global scope of both IS practice and academy, in our study, we aim to provide an international perspective.

3 Research Design

3.1 The Delphi Method

We used the Delphi method to explore grand challenges for IS research. The method allows for "structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem" (Linstone and Turoff 1975, p. 3), and is an accepted method in IS research that is frequently used to forecast and to identify and prioritize important issues (Okoli and Pawlowski 2004). While no single standardized way to conduct a Delphi study exists, there are general principles that are usually followed: First, the participants of the study should be a group of experts in the respective field. Second, a Delphi study consists of different phases, which can, but do not have to, include brainstorming, consolidation, and ranking (Okoli and Pawlowski 2004). Third, each phase may consist of more than one survey

round, which is typically aimed at generating a consensus among the participating experts. This process is supported by providing participants, within each phase, with feedback based on the results of previous rounds. Finally, the goal of a Delphi study must be determined. Goals can be roughly divided into prediction and conceptualization. In the following, we describe our research procedure (see also Fig. 1).

3.2 Preliminary Phase

The project commenced with a workshop with 14 IS experts (nine full professors, four associate professors, and one senior lecturer) from nine different countries (Finland, France, Germany, Italy, Liechtenstein, Lithuania, Norway, Poland, and South Korea). This initial sample was a convenience sample as we took advantage of a meeting of a group of international IS scholars, all of whom can be considered to be experts in the field, and the sample was thus considered to be appropriate. Online Appendix A.1 provides demographics of the participants of the preliminary phase. The participants were given an introduction into the topic of grand challenges and were then asked to write down two or three challenges of IS research. The results were presented and discussed in the group. Six of the participants became the steering committee that was responsible for monitoring and supporting the study, and making decisions where necessary. The steering committee consolidated the workshop results and proposed a first list of challenges for IS research. This list was input for Phase 1 of the Delphi study (qualitative phase).

3.3 Phase 1: Qualitative Delphi Study

In the first phase, we addressed a group of selected IS experts, one of whom had participated in the initial workshop, and asked for their participation in an online Delphi survey. The sample was thus a purposive sample as the participants were chosen based on their expertise. The 13 participating experts (all of them IS professors) were from twelve different countries (Australia, Austria, France, Germany, Ireland, Italy, Lithuania, New Zealand, Russia, Slovenia, Spain, and Switzerland). Online Appendix A.2 provides demographics of these participants. In the survey, we presented the list of challenges retrieved from the preliminary workshop, provided a short explanation for each challenge, and asked the participants to comment on the issue. We further asked them to propose new potential challenges as well as changes/amendments to existing ones. In order to structure the list of challenges and to provide additional stimulus, it was decided to group the challenges along the three sub-questions related to *external challenges of specific domains that should be solved by IS, challenges that are independent of specific domains*, and *challenges of the IS discipline regarding its further development*.

The results of the survey were consolidated by the steering committee and used as input for a second online survey (i.e., the second round of this qualitative Delphi

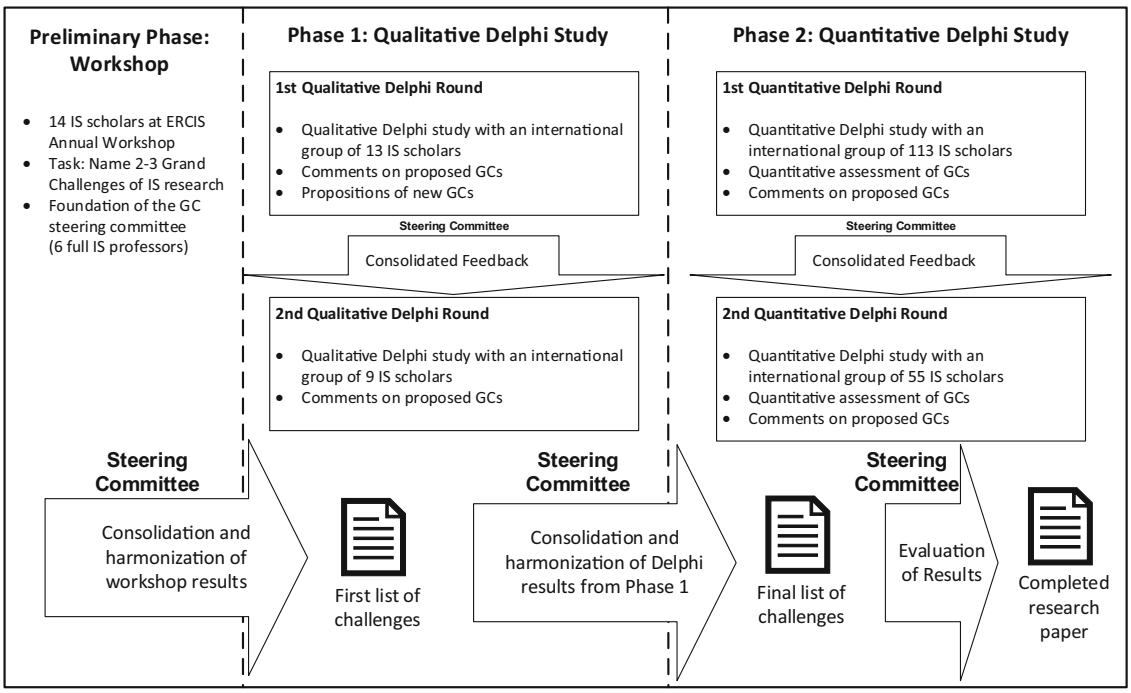

Fig. 1 Research procedure

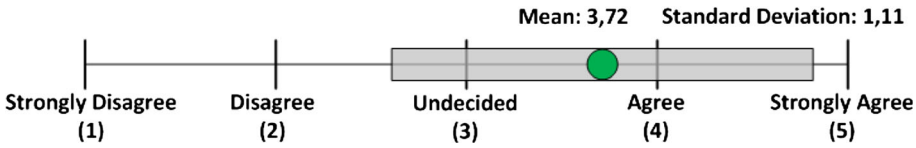

Fig. 2 Example for the feedback depiction of the mean and standard deviation

phase). Those participants who proposed new challenges were asked to provide an explanatory text for these. All new challenges that were provided with an explanation were included in the second round. In accordance with the general principles of Delphi studies, the second survey also contained the aggregated results from the first round as feedback for the participants. This feedback consisted of all (partly paraphrased) comments from the first round. The same participants were asked to revise their comments and to comment on the new challenges, thereby considering the feedback/comments from the other experts. Nine of the previous 13 experts participated in the second round. Moreover, in the second round, participants could classify their own comments using the following items: "I totally agree with this grand challenge", "I would change/edit this grand challenge", "I would merge this grand challenge with one or more other grand challenges", "I would split this grand challenge into two or more grand challenges", "I totally disagree with this grand challenge and would remove it from this survey", and "None of the above". Depending on the classification, the steering committee took according action. For example, if the majority of participants classified their comments for a specific challenge as "agree", this challenge was included in the second Delphi phase; if most participants classified their comments as "disagree", the challenge was excluded from the second Delphi phase. For the classifications edit, merge, and split, the steering committee made decisions based on the comments to edit, merge or split the respective challenges. The final list of challenges served as input for Phase 2 (quantitative phase). Notably, some challenges that were included in this list were discussed controversially – lending some evidence towards the assumption that there is no common understanding of what constitutes grand challenges in IS research.

3.4 Phase 2: Quantitative Delphi Study

In the second phase, we addressed a larger group of IS researchers through an online survey instrument. In the first round of this phase, 112 IS researchers from 21 countries (Australia, Austria, Canada, Czech Republic, Denmark, Faroe Islands, Finland, France, Germany, Italy, Lithuania, Netherlands, New Zealand, Norway, Poland, Russia, Slovenia, Sweden, Switzerland, United Kingdom, and United States) participated. The survey presented the challenges from the first phase (including a short explanation for each), and the participants were asked to rate these challenges (on a five-point Likert scale) regarding relevance, impact, and time frame for the solution of each challenge.

The participants were further asked whether they think that the presented challenge is a grand challenge of IS research—or not. In the survey, we explicitly used the term 'issue' instead of 'grand challenge' to leave it open for the participants to think of an issue as a grand challenge or not. In the end of the survey, participants were asked to pick those three challenges they considered the most important ones, and rank them accordingly.

We invited the participants of the first survey round to participate in a second survey round. Of the 112 participants from the first round, 55 respondents from 18 different countries (Australia, Austria, Canada, Czech Republic, Finland, France, Germany, Italy, Netherlands, New Zealand, Norway, Poland, Russia, Slovenia, Sweden, Switzerland, United Kingdom, and United States) participated in the second round. We provided the same survey, but presented the aggregated results from the first round next to each survey item. The results were visualized through a boxplot visualization showing the mean value and standard deviation for each item. Figure 2 visualizes the criterion 'impact' of a specific challenge.

The participants were asked to complete the survey again, this time under consideration of the first round's results. Furthermore, the participants were provided with the opportunity to state comments for each challenge (divided into pro and contra) in order to better understand their rationale.

4 Results

4.1 Phase 1: Qualitative Delphi Study

The preliminary workshop produced a list of 15 challenges as well as short explanatory texts. These texts were used to describe the challenges in the survey in order to avoid possible misunderstandings.

After consolidating the results of the second survey round, the total of 27 challenges was condensed to a final set of 21 challenges based on the comments made by respondents as well the analysis of the participants' classification. Table 1 shows the final list of challenges (in no specific order), including the history of each challenge. Descriptions of each challenge can be found in Online Appendix A.

Table 1 Challenges for IS research identified from the qualitative delphi study

Challenges for IS research	History
C01 – identifying IS as an academic discipline	W
C02 – adapting IS teaching to current IS research developments	W
C03 – proving relevance of IS research	W
C04 – rethink the theoretical foundations of the IS discipline	New
C05 – streamlining and providing equal quality standards for different strands of IS research	New, E
C06 – mastering the methodological breadth/richness	New, E
C07 – increasing theoretical/methodological sophistication	New
C08 – providing ubiquitous access to IS services	W
C09 – integrating information systems in one single virtual space	W, E
C10 – making different IT generations work together	W
C11 – developing universal methods for the translation between different coding systems	W, E
C12 – aligning organizational objectives with IT by developing and establishing efficient communication means	W
C13 – developing model–driven methods and tools for the full–scale automated generation of implementation–ready IS	New, E
C14 – leveraging the "fun" in information systems applications	New
C15 – integrating human and machine problem solving	New
C16 – leveraging knowledge from data, with the related management of high data volumes	New, E
C17 – developing effective IS for emergency management	W
C18 – utilizing energy informatics	W
C19 – supporting effective collaboration and learning through evolving media repertoires	W
C20 – raising collective consciousness	W
C21 – embedding systems in real–life environments	W, E

W = proposed in preliminary workshop; New = proposed in first qualitative round; E = edited according to comments from 1st and 2nd round

4.2 Phase 2: Quantitative Delphi Study

The quantitative phase of the study terminated after two rounds. The average standard deviation for the three criteria largely remained the same between the first and the second round (relevance: −0.04; impact: −0.09; timeframe: +0.15). It was thus concluded that a third Delphi round would not lead to significantly higher levels of consensus among the participants. At this stage, the participants had relatively stable opinions.

The first criterion surveyed was the *relevance* of an issue. Table 2 ranks the 21 challenges regarding their mean value for this criterion, beginning with the challenge with the highest value (i.e., the highest relevance). Overall, for this criterion, the challenges received comparably high values, meaning that on average the participants perceived all challenges as relevant to IS research (or were indecisive in some cases). However, the average standard deviation (0.96) shows that even after the second Delphi round there were different perceptions of the challenges' relevance within the group of participants.

The second criterion surveyed was the *impact* an issue has on the IS field. We define "impact" as the extent of future effects and consequences that may result from solving a respective challenge. Table 3 ranks the issues according to their impact. Again, on average, the participants perceived the impact of all challenges as strong. The rather high average standard deviation (1.0) is an indicator for significant dissent among the participants regarding this criterion.

The third criterion surveyed was the *time frame,* that is, the expected period of time an issue needs to be dealt with/solved. On average, the participants either agreed with the time frame of ten years or expected solving the issues to take even longer. The average standard deviation (1.12) once more indicates a dissent among the participants (Table 4).

Table 5 provides an overview of the percentage of respondents that rated a challenge to be a grand challenge. This item was included because of some comments from the first phase, where participants had stated that several challenges actually did not qualify for being considered grand challenges, but were rather (nevertheless important) *issues.* While the responses might depend on how the term grand challenge is defined, we deemed it relevant to ask for the participants' opinions. It became obvious that participants tended to consider the challenges C11 (developing universal methods for the translation between different coding systems), C14 (leveraging the "fun" in information systems applications), C13 (developing model-driven methods and tools for the full-scale automated generation of implementation-ready IS), C20 (raising collective

Table 2 Relevance ("This issue is relevant in the field of information systems research")

Rank	Challenges for IS research	Mean value	Standard deviation
1	C16 – leveraging knowledge from data, with the related management of high data volumes	4.49	0.758
2	C15 – integrating human and machine problem solving	4.44	0.698
3	C04 – rethink the theoretical foundations of the IS discipline	4.31	0.897
4	C02 – adapting IS teaching to current IS research developments	4.25	0.821
5	C06 – mastering the methodological breadth/richness.	4.16	0.946
6	C12 – aligning organizational objectives with IT by developing and establishing efficient communication means	4.08	0.860
7	C21 – embedding systems in real–life environments	4.04	0.692
8	C03 – proving relevance of IS research	3.98	1.049
9	C08 – providing ubiquitous access to IS services	3.94	1.008
10	C19 – supporting effective collaboration and learning through evolving media repertoires	3.94	0.826
11	C01 – identifying IS as an academic discipline	3.92	1.064
12	C17 – developing effective IS for emergency management	3.84	0.834
13	C05 – streamlining and providing equal quality standards for different strands of IS research	3.80	1.149
14	C09 – integrating information systems in one single virtual space	3.74	0.964
15	C18 – utilizing energy informatics	3.71	0.997
16	C07 – increasing theoretical/methodological sophistication	3.65	1.146
17	C10 – making different IT generations work together	3.65	1.016
18	C14 – leveraging the "fun" in information systems applications	3.63	1.131
19	C13 – developing model–driven methods and tools for the full–scale automated generation of implementation–ready IS	3.53	1.206
20	C20 – raising collective consciousness	3.51	1.084
21	C11 – developing universal methods for the translation between different coding systems	3.44	0.998

Scale: 1 = strongly disagree; 2 = disagree; 3 = undecided; 4 = agree; 5 = strongly agree

consciousness), and GC18 (utilizing energy informatics) not to be 'grand' challenges. Considering that the majority of participants in Phase 1 agreed on the list of 21 challenges, this shows how differently people conceive the term 'grand challenge' (although we introduced our definition at the beginning of each survey).

Table 6 provides a ranking based on the challenges that were identified as the three most important ones by each respondent. Challenges that were ranked first got three points, those ranked second got two points, and those ranked third got one point. Challenges that were not ranked by any participant got zero points. Perusing this method, we received a ranking which was slightly different to, for instance, the ranking according to their relevance.

5 Discussion and Implications

The Delphi study produced 21 challenges that were evaluated according to relevance, impact, timeframe, significance, and importance. The analysis of our data displays a diversity of challenges, which can be roughly distinguished into those pertaining to the IS discipline and its development (meta challenges for developing the IS discipline), and those pertaining to the actual problems the discipline could solve (IS research challenges). Within the category of IS research challenges, we identify four common themes that are appropriate to further structure the research challenges. In what follows, we first discuss the meta challenges and then turn to the IS research challenges identified through our analysis.

5.1 Meta Challenges for Developing the IS Discipline

Six out of the top ten challenges that were identified relate to issues concerning the development of the IS discipline itself (cf. Table 6). As the most important one the respondents identified "proving relevance of IS research" (rank 1 in overall importance, rank 3 in that it is a grand challenge, and rank 4 in impact). Further challenges include "identifying IS as an academic discipline" (rank 4), "rethink the theoretical foundations of the IS discipline" (rank 5), "mastering the methodological breadth/richness" (rank 6), "adapting IS teaching to current IS research developments" (rank 9), "increasing theoretical/methodological sophistication" (rank 10), and

Table 3 Impact ("The solution of this issue will have a strong impact on the information systems discipline")

Rank	Challenges of IS research	Mean value	Standard deviation
1	C16 – leveraging knowledge from data, with the related management of high data volumes	4.31	0.707
2	C15 – integrating human and machine problem solving	4.13	0.817
3	C04 – rethink the theoretical foundations of the IS discipline	4.12	0.832
4	C03 – proving relevance of IS research	3.98	1.029
5	C06 – mastering the methodological breadth/richness	3.90	0.944
6	C02 – adapting IS teaching to current IS research developments	3.84	0.880
7	C08 – providing ubiquitous access to IS services	3.70	1.030
8	C01 – identifying IS as an academic discipline	3.69	1.130
9	C05 – streamlining and providing equal quality standards for different strands of IS research	3.69	1.122
10	C12 – aligning organizational objectives with IT by developing and establishing efficient communication means	3.67	1.043
11	C21 – embedding systems in real–life environments	3.67	0.909
12	C07 – increasing theoretical/methodological sophistication	3.63	1.076
13	C14 – leveraging the "fun" in information systems applications	3.49	1.189
14	C19 – supporting effective collaboration and learning through evolving media repertoires	3.48	1.019
15	C13 – developing model–driven methods and tools for the full–scale automated generation of implementation–ready IS	3.43	1.204
16	C10 – making different IT generations work together	3.39	1.097
17	C09 – integrating information systems in one single virtual space	3.38	1.130
18	C18 – utilizing energy informatics	3.35	1.027
19	C20 – raising collective consciousness	3.31	1.049
20	C17 – developing effective IS for emergency management	3.20	0.775
21	C11 – developing universal methods for the translation between different coding systems	3.19	1.011

Scale: 1 = strongly disagree; 2 = disagree; 3 = undecided; 4 = agree; 5 = strongly agree

"streamlining and providing equal quality standards for different strands of IS research" (rank 15). These challenges relate to themes recurrently discussed in the IS field, such as relevance, theoretical foundations, methods, and IS identity. Moreover, the study highlights challenges related to IS teaching. Overall, the results suggest a tendency to formulate generic challenges. It has been asserted that the IS discipline is still in its infancy with regard to its level of specialization, compared to other disciplines (Schwartz 2014). Table 7 provides an overview of those challenges pertaining to further developing the academic IS field.

It is interesting to see that "proving relevance of IS research" was identified as a highly important challenge (rank 1 in overall importance, rank 3 in being a grand challenge, and rank 4 in impact). However, as we investigate the community of inquirers, it is not surprising that the respondents are self-referential. Many scholars have pointed out that the IS discipline should focus on topics that are relevant to practitioners and should provide knowledge that can be implemented and is accessible (Benbasat and Zmud 2003; Rosemann and Vessey 2008). Our findings suggest that the old debate about rigor and relevance in IS research is still ongoing.

Two challenges relate to the theoretical foundation of IS, namely "rethink the theoretical foundations of the IS discipline", and "increasing theoretical/methodological sophistication". The study thus confirms prior work, which has discussed the lack of foundational IS theory and which calls to develop theory in IS (Watson 2001). Currently, IS tends to borrow theory from a number of reference disciplines. We interpret this as a call to further develop the theoretical core of our discipline (Urquhart and Fernández 2013; Seidel and Urquhart 2013).

The respondents identify "mastering the methodological breadths and richness of the IS discipline" as a grand challenge. IS is methodologically plural, and researchers draw on different paradigms such as interpretivism, positivism, and critical realism, and apply a multitude of different research methods (Benbasat and Weber 1996). While prior debates have suggested that IS should favor certain methods and certain research approaches (Lyytinen et al. 2007; Österle et al. 2010), our study suggests that the community of inquirers appreciates a diversity of methods and paradigms, and sees a challenge in better understanding how they relate to and complement each other. This is consistent with the idea of "disciplined methodological

Table 4 Time frame ("This issue can be dealt with/solved in 10 years from now on")

Rank	Challenges of IS research	Mean value	Standard deviation
1	C20 – raising collective consciousness	4.43	1.253
2	C11 – developing universal methods for the translation between different coding systems	4.42	1.109
3	C15 – integrating human and machine problem solving	3.98	0.852
4	C01 – identifying IS as an academic discipline	3.92	1.218
5	C13 – developing model–driven methods and tools for the full–scale automated generation of implementation–ready IS	3.92	1.163
6	C18 – utilizing energy informatics	3.83	1.133
7	C09 – integrating information systems in one single virtual space	3.79	1.026
8	C05 – streamlining and providing equal quality standards for different strands of IS research	3.76	1.595
9	C07 – increasing theoretical/methodological sophistication	3.75	1.055
10	C12 – aligning organizational objectives with IT by developing and establishing efficient communication means	3.73	1.050
11	C16 – leveraging knowledge from data, with the related management of high data volumes	3.73	0.850
12	C10 – making different IT generations work together	3.73	1.201
13	C04 – rethink the theoretical foundations of the IS discipline	3.69	1.058
14	C14 – leveraging the "fun" in information systems applications	3.57	1.432
15	C06 – mastering the methodological breadth/richness	3.55	1.101
16	C21 – embedding systems in real–life environments	3.45	1.045
17	C08 – providing ubiquitous access to IS services	3.40	1.166
18	C03 – proving relevance of IS research	3.35	1.110
19	C17 – developing effective IS for emergency management	3.29	0.855
20	C19 – supporting effective collaboration and learning through evolving media repertoires	3.13	1.010
21	C02 – adapting IS teaching to current IS research developments	3.04	1.148

Scale 1: = It will take significantly shorter; 2 = It will take shorter; 3 = The time frame fits; 4 = It will take longer; 5 = It will take significantly longer

pluralism" (Landry and Banville 1992). We would agree with this view, and reference the dialectic of design-oriented research and behavioral research (Gregor and Hevner 2013).

"Identifying IS as an academic discipline" was ranked fourth in importance, and thus confirms the debate that has been coined as the IS identity crisis (Benbasat and Zmud 2003). While some may consider the debate an old chestnut (Seidel and Watson 2014), it still appears to be alive. It has been suggested that the IS discipline may model other disciplines, such as medicine, and follow a strategy of unification and specialization (Schwartz 2014). Identifying grand challenges may contribute to such a development, help fostering the identity of the discipline, and allocate resources to where they are most needed.

"Adapting IS teaching to current IS research developments" was identified as the ninth most important challenge. The respondents thus see a gap between research and teaching, and this gap may be explained by the comparably high dynamics of our field. While the alignment between teaching and research is at the core of university education, we often struggle to update textbooks and curricula under consideration of the latest developments in our discipline. Another problem may be seen in the lack of foundational theory – IS *is* still a young field. As a discipline, we should evaluate new institutional arrangements for IS teaching. Apart from textbooks, recent contributions can be provided to students in the form of journal, conference, or newspaper articles, seminars provide appropriate settings to discuss current topics, and IS can be used in order to improve collaboration in teaching. We must walk the talk, and our students need to be exposed to practical problems – after all, IS is an applied discipline that seeks to improve practice.

5.2 IS Research Challenges

The identified IS research challenges fall into the four categories of *socio-technical challenges, IS infrastructure challenges, societal and ecological challenges,* and *social and affective challenges.* Table 8 provides an overview of IS research challenges, that is, challenges related to problems that might be solved through IS research.

Table 5 Yes/no ("Overall, do you think that the issue above is a grand challenge for IS research?")

Rank	Challenges of IS research	Yes (%)	No (%)	No answer (%)
1	C04 – rethink the theoretical foundations of the IS discipline	74.5	14.5	10.9
2	C16 – leveraging knowledge from data, with the related management of high data volumes	74.5	14.5	10.9
3	C03 – proving relevance of IS research	72.7	18.2	9.1
4	C15 – integrating human and machine problem solving	72.7	14.5	12.7
5	C06 – mastering the methodological breadth/richness	65.5	23.6	10.9
6	C21 – embedding systems in real–life environments	60.0	29.1	10.9
7	C01 – identifying IS as an academic discipline	54.5	36.4	9.1
8	C12 – aligning organizational objectives with IT by developing and establishing efficient communication means	54.5	36.4	9.1
9	C19 – supporting effective collaboration and learning through evolving media repertoires	50.9	43.6	5.5
10	C07 – increasing theoretical/methodological sophistication.	47.3	40.0	12.7
11	C09 – integrating information systems in one single virtual space	45.5	45.5	9.1
12	C17 – developing effective IS for emergency management	43.6	47.3	9.1
13	C08 – providing ubiquitous access to IS services	40.0	50.9	9.1
14	C10 – making different IT generations work together	40.0	49.1	10.9
15	C02 – adapting IS teaching to current IS research developments	34.5	54.5	10.9
16	C05 – streamlining and providing equal quality standards for different strands of IS research	34.5	36.4	29.1
17	C18 – utilizing energy informatics	32.7	56.4	10.9
18	C20 – raising collective consciousness	30.9	47.3	21.8
19	C13 – developing model–driven methods and tools for the full–scale automated generation of implementation–ready IS	23.6	61.8	14.5
20	C14 – leveraging the "fun" in information systems applications	21.8	58.2	20.0
21	C11 – developing universal methods for the translation between different coding systems	16.4	65.5	18.2

5.2.1 Socio-Technical Challenges

Five out of 21 challenges relate to challenges of integrating social and technical aspects of systems design, use, and impact: "integrating human and machine problem solving" (rank 2), "leveraging knowledge from data, with the related management of high data volumes" (rank 3), "supporting effective collaboration and learning through evolving media repertoires" (rank 8), "developing model-driven methods and tools for the full-scale automated generation of implementation-ready IS" (rank 11), and "aligning organizational objectives with IT by developing and establishing efficient communication means" (rank 12). These results reflect the foundation of IS in socio-technical systems (Bostrom et al. 2009; Bostrom and Heine 1977). Relevant contributions to the IS body of knowledge require the simultaneous consideration of the technical and the social subsystem (Gregor 2006). The identified challenges concern questions of how IS can contribute and support human activities such as problem solving, collaboration, communication, and learning as well as how technological and social subsystems can be successfully integrated.

It is interesting to see that fundamental topics such as the alignment of organizational objectives and IT (Reich and Benbasat 2000; Becker et al. 2015), which have been on the agenda for more than two decades (Henderson and Venkatraman 1993), are indeed still seen as a challenge. This supports the argument that IS is still lacking foundational theory and applicable knowledge in important fields.

5.2.2 IS Infrastructure Challenges

Four of the identified challenges relate to IS infrastructures: "providing ubiquitous access to IS services" (rank 7), "integrating information systems in one single virtual space" (rank 13), "embedding systems in real-life environments" (rank 16), and "developing universal methods for the translation between different coding systems" (rank 17). IS infrastructures afford action possibilities for groups of users (Markus and Silver 2008; Volkoff and Strong 2013). Consequently, IS must investigate (a) how such infrastructures are developed and (b) what action possibilities they proffer to what group of users. This has important implications for practice: First, organizations, when implementing IT infrastructures, must carefully consider which groups will use these infrastructures for which purposes. Second, existent infrastructures can be re-evaluated in the light of new, emergent action goals.

Table 6 Top 3 ("Please choose and rank those three grand challenges from the list that are in your opinion the most important ones")

Rank	Challenges of IS research	Total points
1	C03 – proving relevance of IS research	47
2	C15 – integrating human and machine problem solving	42
3	C16 – leveraging knowledge from data, with the related management of high data volumes	32
4	C01 – identifying IS as an academic discipline	28
5	C04 – rethink the theoretical foundations of the IS discipline	16
6	C06 – mastering the methodological breadth/richness	14
7	C08 – providing ubiquitous access to IS services	12
8	C19 – supporting effective collaboration and learning through evolving media repertoires	11
9	C02 – adapting IS teaching to current IS research developments	10
10	C07 – increasing theoretical/methodological sophistication	9
11	C13 – developing model–driven methods and tools for the full–scale automated generation of implementation–ready IS	8
12	C12 – aligning organizational objectives with IT by developing and establishing efficient communication means	7
13	C09 – integrating information systems in one single virtual space	7
14	C14 – leveraging the "fun" in information systems applications	7
15	C05 – streamlining and providing equal quality standards for different strands of IS research	4
16	C21 – embedding systems in real–life environments	2
17	C11 – developing universal methods for the translation between different coding systems	2
18	C17 – developing effective IS for emergency management	2
19	C10 – making different IT generations work together	2
20	C20 – raising collective consciousness	2
21	C18 – utilizing energy informatics	1

Rating: rank 1 = 3 points; Rank 2 = 2 points; Rank 3 = 1 point; Not ranked = 0 points

Table 7 Meta challenges pertaining to further developing the academic IS field

C03 – Proving relevance of IS research
C01 – identifying IS as an academic discipline
C04 – rethink the theoretical foundations of the IS discipline
C06 – mastering the methodological breadth/richness
C02 – adapting IS teaching to current IS research developments
C07 – increasing theoretical/methodological sophistication

5.2.3 *Societal and Ecological Challenges*

Three of the identified challenges relate to important social challenges: "developing effective IS for emergency management" (rank 18), "raising collective consciousness" (rank 20), and "utilizing energy informatics" (rank 21). This is consistent with a general tendency in IS research towards increased sensitivity for societal problems (e.g., Elliot 2011; Melville 2010; vom Brocke et al. 2013), reflected in recent special issues on Green IS (e.g., MIS Quarterly, Journal of Strategic Information Systems) or conference themes such as "Building a Better World through Information Systems" at ICIS 2014 or "Reshaping Society Through Information Systems Design" at ICIS 2013. We contend that IS has much to offer to solve global challenges as the IS field is concerned with nothing less than the "central task of managing the information of mankind" (Schwartz 2014, p. 3).

5.2.4 *Social and Affective Challenges*

Two further challenges refer to the social and affective aspects of IS: "leveraging the 'fun' in information systems applications" (rank 14) and "making different IT generations work together" (rank 19). Prior IS research has not considered these issues in much depth. Incorporating affective aspects related to the design, use, and impact of information systems is an emergent field, and efficiency gains through concepts such as gamification (e.g., Andonova 2013) or IT consumerization (e.g., Köffer et al. 2014) have been considered only recently. For instance, the field of NeuroIS has been proposed to systematically investigate affective effects through the measurement and analysis of neuro-physiological data (Dimoka et al. 2012; Riedl et al. 2010). Studying the social and affective aspects thus calls for interdisciplinary research that affords the IS discipline to draw on theories from reference disciplines or, in the best case, collaborate with scholars from these disciplines. The example of NeuroIS is a commendable example,

Table 8 IS research challenges

Theme	Research challenges
Socio-technical challenges	C15 – integrating human and machine problem solving
	C16 – leveraging knowledge from data, with the related management of high data volumes
	C19 – supporting effective collaboration and learning through evolving media repertoires
	C13 – developing model-driven methods and tools for the full-scale automated generation of implementation-ready IS
	C12 – aligning organizational objectives with IT by developing and establishing efficient communication means
IS infrastructure challenges	C08 – providing ubiquitous access to IS services
	C09 – integrating information systems in one single virtual space
	C21 – embedding systems in real-life environments
	C11 – developing universal methods for the translation between different coding systems
Societal and ecological challenges	C17 – developing effective IS for emergency management
	C20 – raising collective consciousness
	C21 – utilizing energy informatics
Social and affective challenges	C14 – leveraging the "fun" in information systems applications
	C10 – making different IT generations work together

where well-established methods from the field of neuroscience, which is traditionally rooted in the natural science of biology, are now used to study IS-related phenomena, typically based on experimental research.

6 Limitations

This study has several limitations. First, it presents challenges from the perspective of the community of inquirers and may thus be regarded self-referential. Still, a community of inquirers has its own context and builds upon intersubjective agreements – and one way to understand these intersubjective agreements is to ask those who are involved. Second, it cannot be excluded that the original list provided as input for the first phase of the Delphi study biased subsequent steps. Still, we ensured that participants were given the chance to add further challenges and comment on those proposed in earlier rounds. Third, we acknowledge that different researchers may have grouped the identified challenges into other categories.

Most notably, it is possible that the replication of the study with a different sample would reveal different results. The sample involved in the Delphi study is not representative for the IS discipline, any specific sub-fields, or the countries involved. In particular, the Anglo-American IS community, which has much impacted IS research since its inception, is underrepresented. Mertens and Barbian (2015) investigated grand challenges with a focus on the German-speaking community and identified a set of (partly) different challenges. At this, it is notable that the German-speaking IS community highlights the role of engineering and design. The different views and opinions show that a common set of IS research challenges, which every group of international researchers can agree upon, does not yet exist.

7 Summary: Grand Challenges or Just Challenges?

In this paper we have presented the results of a Delphi study that aimed to identify grand challenges of IS research – but are the identified challenges indeed *grand* challenges? We argue that the identified challenges provide important insights into the beliefs held in – at least parts of – the community of inquirers that constitutes the IS discipline. The results illustrate how the IS discipline is both self-reflective and concerned with solving practical issues, even at a global level. On the one hand, the study shows that the IS discipline is still much concerned with itself, and that the old debate about IS identity is still alive – finding an identity, proving relevance, creating foundational theory, or mastering the methodological pluralism are still seen as major challenges. On the other hand, the Delphi study has highlighted challenges of solving concrete, important problems related to communication and collaboration, social progress, or sustainability. Ultimately, IS research is a practical discipline that needs to serve the goals of society and thus has to understand what society demands (Seidel and Watson 2014). As a discipline, we must understand what tangible accomplishments we can achieve for the betterment of society. We thus promote the stance that doing research in relevant fields – as those suggested by the participants of our Delphi study –

will further help our field find its identity and prove its relevance. Thus, it remains open whether the challenges identified in this study are "grand". In many discussions about the topic, some of the participants asked whether the challenges are visionary enough to deserve this label. Through our work, we have attempted to contribute to the debate on grand challenges of our discipline in order to improve its impact and societal relevance. It is in the very nature of debates that alternative opinions, viewpoints, and studies using different samples and methods must follow. May these opinions and views result in an ongoing debate about the challenges IS research faces.

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