Journey Towards Agility: Where Are We Now And Where Are We Heading?

Short Paper

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Abstract

After more than 15 years since the Agile Manifesto and extensive research on agile information system development (AISD), a comprehensive body of knowledge is available and is constantly growing. AISD is considered an effective way for managing ISD projects in environments characterized by rapidly changing requirements. This study aims to shed light on the existing knowledge on AISD by applying a structured literature review and computer aided analysis consisting of distinct text mining techniques. We plan to analyze a sample of more than 10,000 articles and provide preliminary results of a subset of 327 articles of the Senior Scholars' Basket and selected conferences. Based on our approach, we are able to (1) evaluate key articles, authors, and journals, (2) analyze the development of AISD research in the last two decades and, most importantly, (3) identify research foci of the past as well as gaps in our knowledge on AISD.

Keywords: Agile, Agile Software Development, Software Development, Computer Aided Analysis, CAA, Information System Development, ISD, Literature Review, Text Mining, Topic Modelling

Introduction

Interest in agile information system development (AISD) methodologies has increased in recent years (Conboy 2009; Dybå and Dingsøyr 2008; Fitzgerald et al. 2006a; Lee and Xia 2010; Williams 2012). Based upon the principles of the Agile Manifesto (Beck et al. 2001), different implementations, such as Scrum or eXtreme Programming (XP), have emerged and motivated a variety of research.

AISD has been applied to a wide range of projects: from small teams, situated in co-located offices (e.g., Cao et al. 2009; Ghobadi and Mathiassen 2016) to large-scale, distributed, or outsourced projects (e.g., Berger and Beynon-Davies 2009; Goh et al. 2013; Persson et al. 2012; Ramesh et al. 2012; Sarker and Sarker 2009). In this context, AISD methodologies and practices have been implemented successfully but also unsuccessfully (Lee and Xia 2010). Research has investigated the customization and configuration of agile approaches, the so-called method tailoring (e.g., Fitzgerald et al. 2006a; Karlsson and Ågerfalk 2009; Wang et al. 2012). Due to the wide variety of topics covered by AISD research, ranging from rather technical aspects (e.g., Balijepally et al. 2009) to sociological or psychological factors (e.g., Hong et al. 2011; Maruping et al. 2015) and from an individual level to an organizational level (e.g., Zheng et al. 2011), a clear categorization of existing streams of research is difficult to recognize. Additional difficulties arise, as the concept of AISD, its exact definition, and its applicability are debated (Conboy 2009).

Motivated by this, our study's objective is twofold. First, we ask, which topics of AISD research are currently investigated. Second, we want to investigate topics, which are not covered in current research projects and therefore still remain non-existent in extant literature. Consequently, the central research questions guiding our study are: *(1) What research topics have been addressed within the last two decades by AISD research and (2) how do these topics differ in terms of available publications and their distribution over time?*

To answer our research questions, we conducted a structured and comparative literature review on the extant body of knowledge of AISD approaches following the guidelines of Levy and Ellis (2006) and Webster and Watson (2002).

The remainder of this paper is structured as follows. We give an overview about related work, targeting research on the field of AISD. Next, we describe our research design being used for data collection and analysis. Following, we present our preliminary findings and finally, we provide an outlook for and point out future research directions.

Related work

Information systems are often developed in the form of projects (Hirschheim et al. 1995, p. 33), with many different involved stakeholders and team members (Chae and Poole 2005). Many aspects of information system development are intangible in nature (Cule et al. 2000). All of this makes the coordination of activities demanding (Kraut and Streeter 1995). Stakeholders are confronted with many uncertainties and ambiguities, which can lead to failure of the whole process (Cule et al. 2000).

In practice, approaches for developing information systems range from sequential approaches (Royce 1970) to more cyclic, iterative approaches (Boehm 1988), that is AISD. During the last two decades, AISD methodologies, such as eXtreme programming (Beck and Andres 2004), rapid application development (Martin 1991), or rapid prototyping, complemented the iterative approach. Additionally, new management concepts, associated with AISD, such as Scrum (Schwaber 1995) and Lean Software Management (Poppendieck and Poppendieck 2003), have been proposed.

The four basic principles of the Agile Manifesto (Beck et al. 2001) can be found in most AISD methodologies. According to the Agile Manifesto, AISD should value individuals and interactions over processes and tools, working software over comprehensive documentation, customer collaboration over contract negotiation, and responding to change over following a plan (Beck et al. 2001). Each of these principles have been subject of research in some sort: for instance, in regard to individuals and interactions, research has investigated the effects of communication in AISD teams (Hummel et al. 2015), in regard to working software, extant literature investigated the influence of pair programming on software quality (Balijepally et al. 2009), in regard to customer collaboration, the funding process has been studied (Cao et al. 2013), and the ability to respond to change has been subject of case studies as well (Fitzgerald et al. 2006a).

In addition to the historical foundation of AISD, current AISD methodologies (Cao et al. 2009; Vidgen and Wang 2009) appear to incorporate most of the practical lessons learned about ISD during the past years (Cockburn and Highsmith 2001; Highsmith and Cockburn 2001): they prefer more flexibility and autonomy within the team over strict control, the overall development process is not planned and scheduled upfront, and progress is made in small iterative phases, while encouraging change and constant feedback (Dybå and Dingsøyr 2008; Lee and Xia 2010; Maruping et al. 2009a). Planning becomes a permanent task, and team leadership is established via team collaboration, while team leadership is separated from project lead (Dybå and Dingsøyr 2008; Dybå and Dingsøyr 2009).

Extant research in the field of AISD methodologies so far has studied individual or organizational phenomena, such as the use and effects of specific agile practices (Balijepally et al. 2009; Holmqvist and Pessi 2006; Maruping et al. 2009b), and effects regarding whole projects or organizations, such as the introduction of AISD methodologies to teams (Cao et al. 2009; Heeager 2012; Hong et al. 2011; Kotlarsky 2007; Mangalaraj et al. 2009). Furthermore, the use of hybrid methodologies or the tailoring of agile methodologies to a team's specific needs is covered by extant research (Karlsson and Ågerfalk 2009; Lee and Xia 2010; Wang et al. 2012).

Literature investigating the success and failure of AISD mostly focusses on specific methodologies, such as Scrum or XP (Fruhling and de Vreede 2006), or specific practices, for instance pair programming (Cao et

al. 2013). Extant research focusing on success and failure of AISD in general exists, but is rare (Lee and Xia 2010).

By conducting a systematic literature review, we assessed the current state of research regarding summarizing and aggregating literature reviews. We searched for articles containing "literature" and "review" as well as a synonym for AISD (i.e., agil*, scrum, xp) in the title, abstract, or keywords. We used the same databases and journals and conferences as we did for our main literature review and as described in Table 1 and Table 2. The search revealed 15 results of which none did a historic-holistic approach as we did, but instead focused on a specific field of interest, such as software engineering for ubiquitous systems (e.g., Guinea et al. 2016), individual acceptance, tailoring, or use of agile methods and practices (e.g., Campanelli and Parreiras 2015; Chan and Thong 2007; Inayat et al. 2015), general practices and challenges in agile requirements engineering (e.g., Inayat et al. 2015), or geographically distributed, large scale AISD and agility (e.g., Alzoubi et al. 2016; Barlow et al. 2011; Dikert et al. 2016; Trinh-Phuong et al. 2012).

We can therefore conclude, that few summarizing or aggregating literature on the field of AISD research exists and that those articles are oftentimes specialized and limited in scope. For instance, AISD has been included in a summary for information systems offshoring (Strasser and Westner 2015). Other aggregating or summarizing literature focuses on the concept of agility itself (Conboy 2009), but only few provide an overview about existing studies (e.g., Dybå and Dingsøyr 2008).

Research method

First phase: structured literature review

This structured literature review aims to answer the research questions by analyzing and evaluating the existing body of research regarding currently investigated research topics as well as existing research gaps in the context of AISD. The approach of a structured literature review is chosen because of the low number of review articles that are being published in the information systems field (Paré et al. 2016; Rowe 2014; Webster and Watson 2002). Reviews are often a means to expose emerging issues to potential theoretical foundations, and because AISD itself is still a continuously emerging topic, this review aims at analyzing the extant research literature to summarize what has already been researched and what is left to be examined. To provide a comprehensive overview on current AISD topics and those topics, that still have to be investigated, the existing literature will be thoroughly examined, using a structured approach by following the guidelines of Levy and Ellis (2006) and Webster and Watson (2002).

Initially, our data collection process started by performing an extensive keyword search within leading journals in order to find relevant research articles as suggested by Webster and Watson (2002). As a first step within our research project, we set a focus on primarily high quality, peer-reviewed literature, published in journals of the "Senior Scholars' Basket of Journals" only. This term refers to a set of eight top rated information system (IS) journals published by the Association for Information Systems (AIS), known for high quality articles in the field of IS (https://aisnet.org/?SeniorScholarBasket). Additionally, we included articles of five prominent IS conferences (see Table 2). In a second step, which is actually not in scope of this research-in-progress paper, we will extend our data to a complete set of relevant journals and other conferences. Other outlets like books will be included. We defined a single search string for our keyword search to identify relevant articles in different databases (see Table 1). As we aimed for an as broad and holistic overview as possible, we only applied minimal include and exclude criteria (see Table 3). We mainly excluded those publications, which were either difficult to automatically analyze via text mining (e.g., non-English language or with no full-text available) or which were not IS-research focused (e.g., an opinion or comment on the state of the IS industry).

Search string used	Name of vendor databases included
TIKEAB:(software OR "information system") AND TIKEAB:(development OR engineering OR maintenance OR method* OR practic*) AND (TIKEAB:(agil* OR SCRUM OR XP OR "Extreme Programming") NOT TIKE:(manufac*))	ACM Digital Library AISeL EBSCO Academic Search Complete EBSCO Business Source Complete EBSCO EconLit IEEEXplore

	ProQuest
	Science Direct
Legend: TIKEAB: search performed on title, keywords and abstract; TIKE= search performed on title and keywords	

Table 1: Search strings and databases used

We decided to use a restriction for the publishing year of the articles, thus, articles that were published between January 1st, 1989 and August 31th, 2016 were included. January 1st, 1989 was chosen because the first article we found was from 1989 and all data was collected in August 2016, which is why we chose August 31st, 2016 as cap. All search results were examined regarding title, abstract, and keywords. Within the resulting set of papers, we further identified relevant articles for our project purpose ("in scope", i.e. investigating AISD) and dropped the others ("not in scope", i.e. not investigating AISD).

In total, after removing duplicates our final set of articles consists of 85 articles matching our search indicators for AISD in journals and 237 articles in conference proceedings, totaling up to 322 articles. Further information concerning the distribution of results can be seen in Table 2.

Journal names (sorted alphabetically)	Results (Σ=85)
European Journal of Information Systems **(EJIS)**	18
Information Systems Journal **(ISJ)**	15
Information Systems Research **(ISR)**	18
Journal of AIS **(JAIS)**	2
Journal of Information Technology **(JIT)**	14
Journal of MIS **(JMIS)**	6
Journal of Strategic Information Systems **(JSIS)**	3
MIS Quarterly **(MISQ)**	9

Conference names (sorted alphabetically)	Results (Σ=237)
Americas Conference on Information Systems **(AMCIS)**	52
European Conference on Information Systems **(ECIS)**	38
Hawaii International Conference on System Sciences **(HICSS)**	100
International Conference on Information Systems **(ICIS)**	23
Pacific Asia Conference on Information Systems **(PACIS)**	24

Table 2: Distribution of results in the Senior Scholars' Basket of Journals & Information System Conferences

Include criteria	Exclude criteria
English language	Other language
Peer-reviewed	Not peer-reviewed
Full-text available	Only abstract available / full-text missing
Information system context	Other context
Research-focused publication	Opinion, comment, or perspective

Table 3: Include and exclude criteria

Second phase: computer aided analysis

Following to the data collection described in 3.1, we analyzed all articles with the help of a computer-aided analysis and text mining tool called MineMyText (MineMyText 2016). MineMyText utilizes a strategy called topic modelling (Aggarwal and Zhai 2012; Debortoli et al. 2016), which uncovers topics shared by different articles. We use this technique to easily discover topics shared across research and therefore to answer our research questions. Research found text mining and especially topic modelling to be helpful in discovery hidden topics by classifying, summarizing, and clustering of text (Alsumait et al. 2010; Maowen et al. 2012;

Srivastava and Sahami 2009) and topic trends over time (Alghamdi and Alfalqi 2015). This semi-automated approach is especially helpful in analyzing large amounts of text (Maowen et al. 2012; Srivastava and Sahami 2009).

In order to analyze the extracted data, we first had to convert the articles into a compatible format by applying optical character recognition and annotating the extracted text with additional information, such as author, year, and title.

A too high number of topics to extract might lead to an excessive number of meaningless topics and a too low number might constrain the results unnecessarily, the number of topics to be extracted is the most crucial parameter of the analysis (Debortoli et al. 2016). Both authors individually and independently each tested the number of topics parameter with 10 to 50 and rated each result set regarding the meaningfulness of the identified topics. After testing and evaluating different amounts of topics, we settled on 30 topics, as it provided differentiated, but not meaningless topics. Furthermore, we decided to use lemmatization (i.e., reducing a word into its dictionary form, e.g., plural to singular, past tense to simple present tense) and n-grams (i.e., creation of consecutive words, e.g. "agile software development") to reduce the number of words with identical meanings but different lexical representations. To further refine the results, we used a list of stop words, which consisted of frequently found words, which added no meaning, such as "et al.", "journal", "research", or "study".
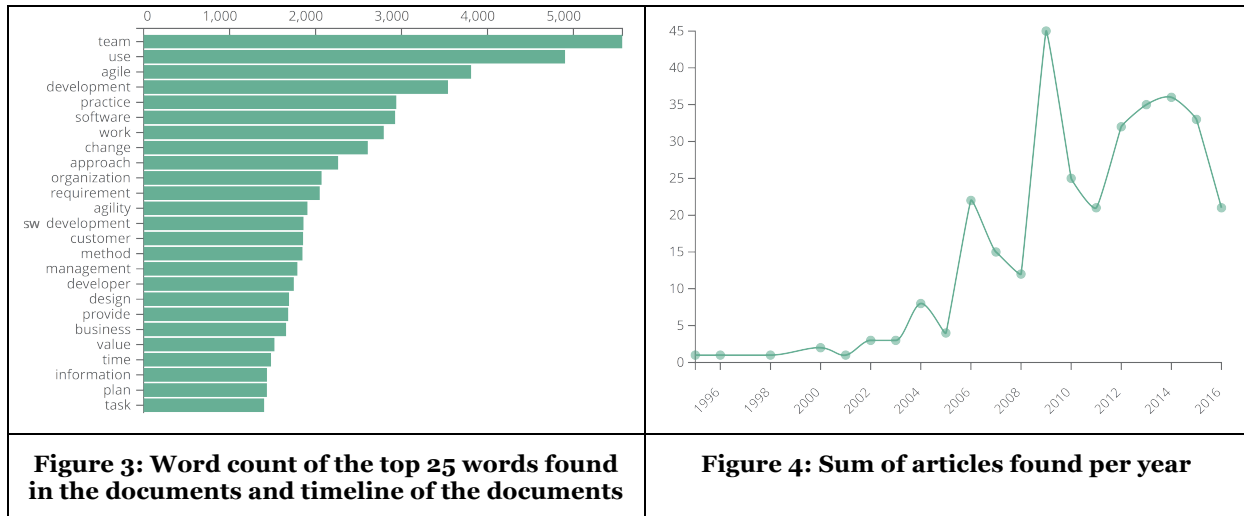
Following Strauss and Corbin (1998) we applied the open coding strategy. At the core is the task of conceptualization: "the process of grouping similar items according to some defined properties and giving the items a name that stands for that common link" (Strauss and Corbin 1998, p. 121). Both authors independently and individually compared all resulting topics against each other, by comparing the included keywords per topic. Based on the keywords, a summarizing title was suggested. In case of matching topic titles, no further action was needed. In case of differing topic titles, the reasoning for each title was compared and alternatives were discussed until a consensus was reached. Similarly, we then tried to group the identified topics into meaningful groups - again first individually, followed by a discussion to find consensus, where needed.

Since some of the identified topics share keywords (e.g., "individual" in "Decision Making", "Knowledge Management", "Adoption", and "Groups, Team Work, & Knowledge Management"), a differentiation between each topic was not always apparent. Rather, the process was a case-by-case discussion about both the meaning of each topic's keywords as well as the order of the keywords for each topic. For instance, while "individual" was mentioned multiple times, it was either one of the fewer mentioned keywords and therefore at the middle or end of the keyword list and therefore less relevant to the topic (e.g. "Decision Making" and "Knowledge Management") or somewhat at the beginning of the list and therefore more relevant to the topic (e.g. "Adoption" and "Groups, Team Work, & Knowledge Management")

In the following, we will present and discuss the preliminary results obtained from this analysis.

Preliminary findings

Figure 1 displays the word count of the 25 most found words across all articles and Figure 2 displays a timeline with the per-year number of articles and supports our research design, as the top words relate to terms related to ISD and agility.

Figure 3: Word count of the top 25 words found in the documents and timeline of the documents	Figure 4: Sum of articles found per year

Regarding identified topics, Table 4 lists identified topics, the superior topics, the keywords contained by each topic, and the rank in terms of frequency of the individual topics. The keywords and topics were extracted from MineMyText (MineMyText 2016) via keyword bubbles.

The most common topic was the topic labelled as "Agile ISD Teams and Agile Practices" since this topic is aggregated of multiple sub-topics, such as "Agile ISD", "Team Work, Autonomy, Structure & Organization", or "Communication, Offshoring & Outsourcing". Furthermore, our preliminary analysis revealed superior topics related to "Management, Requirements Engineering, & Planning", as well as "Organizational Agility".

We decided to differentiate between these superior topics, because of the different foci of the topics themselves: while some topics comprise more general information such as concepts, principles or methodologies related to AISD (see "Agile ISD Teams & Agile Practices"), others focus on an organizational perspective and link agile principles like flexibility or agility to different contexts (see "Organizational Agility"), still others focus on managerial implications (see "Management, Requirements Engineering, & Planning") and put emphasis on certain aspects like roles, planning, risks or performance.

Superior Topic	Topic	Rank	Keywords
Agile ISD Teams & Agile Practices	Agile ISD	1	Practice, theory, method, concept, agility, context, ISD, development, approach, perspective, goal, framework, software development, development, software, methodology, approach, change, agile, organization, method, requirement, environment, management, agile methods, agile develop
	XP, Scrum & Kanban, Agile & Lean Development	6	Practice, agile, agile methods, team, XP, agile practices, developer, method, work, code, refactoring, quality, provide, design, pair programming, agile develop, team, Scrum, sprint, work, coordination, task, dependency, backlog, company, plan, team member, time, Kanban, meet, agile, lean, topic, agile methods, lean software development, agile software development, method, approach, Scrum
	Team Work, Autonomy, Structure & Organization	8	Team, team members, agility, software development, change, task, software, performance, developer, role, autonomy, team, agility, work, agile, plan, lean, software development, developer, change, chaos, structure, XP
	Communication, Offshoring & Outsourcing	9	Communication, team, distribute, practice, challenge, offshore, meeting, development, agile method, coordination, client, outsource, vendor, service, company, offshoring, contract, provider, software, customer, market, supplier
	Management & Roles	4	Interview, manager, agile, developer, role, organization, relationship, work, people

Management, Requirements Engineering, & Planning	Planning & Risk Management	2	Estimate, time, plan, agile, cost, risk, work, change, effort, team, customer, increase, delivery, resource, reduce
	Markets	5	Business, service, technology, game, customer, management, market, development, industry, bank, application
	Strategies & Requirements	7	Development, agile, strategy, framework, approach, challenge, requirement, context, information
	Decision Making	10	Organization, decision, agile, group, mindfulness, case, team, individual, approach, decision making, strategy
	Knowledge Management	11	Knowledge, group, share, organization, knowledge sharing, information, member, individual, collaboration, network, communication, social, student, lean, teach, solution, skill, approach, work, idea, collaboration, knowledge, creativity, problem
	Adoption	12	Adoption, agile, theory, individual, user, lean, acceptance, context, software development, behavior, management, change
	Innovation & Risk Management	13	Innovation, organization, risk, improvement, ambidexterity, change, management, practice, risk management
	Groups, Team Work, & Knowledge Management	14	Group, pair, tasks, effort, individual, work, pair programming, development, performance, knowledge, time, social loafing, partner, social
Organizational Agility	Organizational Agility & Supply Chain	3	Agility, capability, firm, resource, business, organization, sense, change, enable, strategy, information, knowledge, respond, agent, supply chain, information, network, customer, production, order, integration, manufacture, flexibility, firm, business, management, plan, resource, market, supplier, change, demand, operation

Table 4: Identified Topics, including the rank in terms of frequency and included keywords
Superior topics are sorted alphabetically, topics are sorted by their rank, and keywords are sorted according to their frequency in their respective topic

Although at first glance our superior topic clusters presented in Table seem to randomly comprise a lot of different and wide spread themes, further investigation and analysis of our results reveal distinct and meaningful patterns. The resulting topics, consisting of specific keywords, are overlapping but each one of them has its 'raison d'être' as they represent themes, that have been addressed in AISD research within the last ten years. In the following, we will briefly discuss some of our preliminary results, in detail, we analyze the three best-ranked topics as well as the two lowest ranked topics:

As can be seen from Table 4, the most common topic, "Agile ISD", summarizes the basics of AISD. The keywords are centered around AISD methods, concepts, practices, management, and goals. The second most common topic, "Planning & Risk Management", is focused more on project management activities, such as estimation and risk assessment. It is not surprising that planning and risk management is an important topic, as planning and risk management are seen as two of the major critical success factors in ISD (Boehm 1991). The third most common topic, "Organizational Agility & Supply Chain" is on a higher level of abstraction, as it does investigate the AISD usage itself but rather the organizational effects resulting.

On the other hand, the two lowest ranked topics, "Innovation & Risk Management" and "Groups, Team Work, & Knowledge Management", seem to be covered less by AISD research. While there are interrelations between these two and more common topics (e.g., "pair programming" is represented in the 6th and 14th common topic as can "risk" be found in the 2nd and 13th common topic), the more specific nuances (i.e., innovation and team-level research) appear to be peripheral matter to extant research. In contrast to its peripheral appearance, research acknowledges the importance of not only technical but also social focus (Conboy et al. 2011; Maruping et al. 2015).

By further investigation of our timeline regarding the distribution of published articles (see Figure 2) we recognize several interesting findings. First, AISD seems to strongly draw the interest of the research community after the year 2003. Since then, there is a significant increasing slope of the graph, indicating that more articles have been published in the following years. Popular works published within this year are for example Williams and Cockburn's article "Agile Software Development: It's about Feedback and Change" (Williams and Cockburn 2003). All publications have in common that they deal with the topic of AISD from a methodology perspective, putting emphasis on concepts, principles or detailed information concerning a specific approach. Some other articles published in year 2003 deal with the topic of "virtual teams" (e.g., Piccoli and Ives 2003; Sarker and Sahay 2003). This is not surprising, since the concept of virtual teams is seen as an important antecedent for "doing agile" in organizations (Bergiel et al. 2008; Bowen and Maurer 2002; Domino et al. 2002).

Second, we identified a peak in our timeline. Between 2008 and 2009, we see the highest number of articles published within our predefined restriction of years. We found almost 50 articles of journals and conference proceedings dealing with the topic of AISD. One explanation for this may be the call for papers for special issue themes, such as "flexible and distributed ISD" in Information Systems Research (ISR) journal (Fitzgerald et al. 2006b) or previous works, which inspired further research, such as Larman's "Agile and Iterative Development: A Manager's Guide" (Larman 2003) or Poppendieck and Poppendieck's "Lean Software Development: An Agile Toolkit" (Poppendieck and Poppendieck 2003). The special issue was intended to build on the success of a previous special section of Communications of the ACM (Ågerfalk and Fitzgerald 2006a) and mini-track at the 39th Hawaii International Conference on System Sciences (HICSS) in 2006 (Ågerfalk and Fitzgerald 2006b). Ågerfalk and Fitzgerald argued that "it became clear from these efforts that as a very active emerging area of research, there was an imminent need for a forum that allowed for the development and dissemination of full-research papers of the highest quality" (Ågerfalk et al. 2009, p. 318).

Third, we recognize decreasing slopes after 2004 and 2009. One reason for this decrease might be the incomplete coverage of scientific outlets in our current sample and a move from some authors to publish their research (temporarily) elsewhere. As companies dealt with this crisis, they might have been more reluctant to agree to participate in research and due to the time it takes to publish research, one might see these slightly offset slopes.

Conclusion and outlook

Within this short paper, we identified important articles, as well as research topics on AISD methodologies covered by the Senior Scholars' Basket of IS Journals and conferences on IS. Our preliminary findings provide a brief preview of topics, which attracted the attention of the research community dealing with AISD methodologies.

Based on our comparatively small data set which has been available in this early stage of our research, we demonstrated the suitability of computer-aided topic clustering for outlining the current state of AISD research. Although we expect changes regarding the topic ranking with additional journals and other outlets like books, we plan to include more outlets in our analysis in a next step to increase both coverage and validity of our research. Further, we plan to increase the detail of our analysis by analyzing relationships between different topics, especially over time, to identify trends and adjacent or interrelated topics.

By extending our study to a complete set of AISD relevant literature, we will be able to provide an extensive and comprehensive overview about the research domain and foster further research on this important topic. This will be supported by our CAA approach, as we are able to process a large amount of already conducted research into our review, therefore further extending the scientific communities' knowledge about AISD. We are confident that our study results will provide an appropriate degree of generalizability, completeness, and replicability. We described our procedure and sources to ensure replicability, while generalizability and completeness go together for this study. Due to the comprehensive literature basis provided by our structured literature review and the help of a computer-aided analysis, we are able to process extant research at large and discover hidden topics. This research design facilitates generalizability and completeness.

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